FEBRUARY 1961
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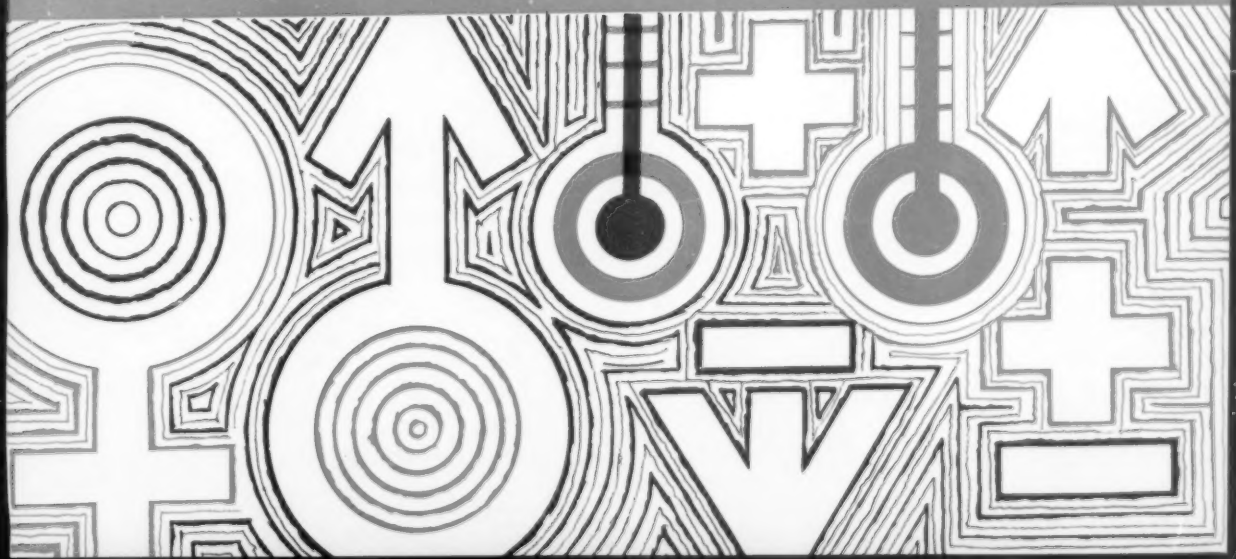
CANADIAN ELECTRONICS ENGINEERING

Low impedance thermoelectric device powers tunnel diodes

New floating laboratory for underwater acoustic measurements

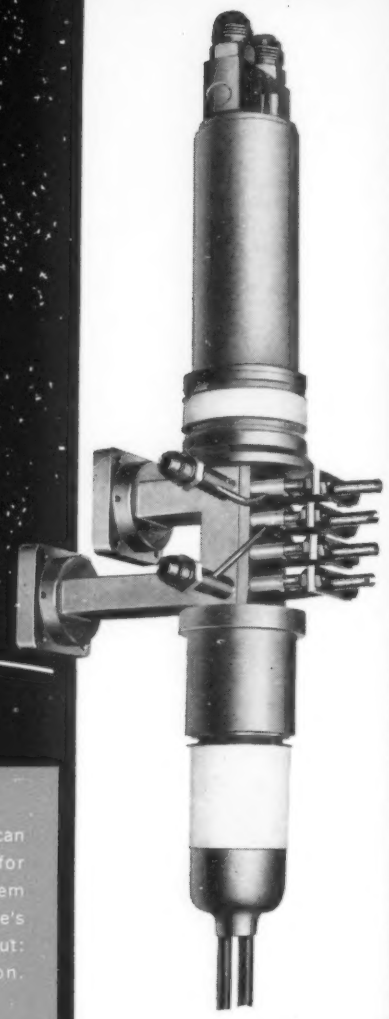
Output hybrid parameter simplifies transistor calculations

Semiconductors provide key to thermoelectric developments



for space systems

20kW CW at X-band



Varian's new VA-849 amplifier klystrons are rated to deliver higher CW power at X-band than any existing tube in the world . . . 20kW!

Varian's new VA-849 power klystron opens up a variety of new design approaches to space systems. Possible applications exist in communication concepts such as repeater satellites, moon-bounce signalling, or in reflections from clouds of tiny orbiting needles. Radio astronomers, too, will welcome the VA-849.

Immediate applications include CW radar and illuminator service. Low incidental noise. Water cooling. Electromagnet focusing. Another significant advance in microwave components from Varian's broad experience and research in super-power tubes.

FEATURES

- **7.125 to 8.5 kMc**
- **20 kW CW**
- **50 db Gain.**
- **30 Mc Minimum Bandwidth**
- **Tunable 60 Mc.**

It's likely that Varian can provide a solution for your particular system design problem. There's a good way to find out: write Tube Division.

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Representatives: Eastern—R-O-R Associates, Toronto, Ottawa and Montreal; Western—Arva, Vancouver

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CANADIAN ELECTRONICS ENGINEERING

Volume five, number **2** **February 1961**

Thermoelectricity — present status and future application

The first five articles in this issue describe some of the latest developments in this new field of semiconductor technology

CONTENTS — continued on page 3

Mercury-wetted contact relays, steel-enclosed and ready for mounting on your own assembly line, give you Clare reliability in operation, combined with new ease of application and handling. Clare HG and HGS relays have test records of over 10 billion operations, without maintenance or change in characteristics. In these new modular cases, they're sturdy, magnetically shielded, easily replaceable.

Choose either the standard Clare HG relay, or the HGS—super-fast and super-sensitive. You'll gain extra convenience and increased component-density with these Clare Relay modules.

Now you can mount CLARE BILLION-OPERATION RELAYS on your own printed circuit board

Typical Clare mercury-wetted relay steel-enclosed modules for circuit-board mounting. From top: HGSM Relay Module, HGM Relay Module, HGPM Relay Module. Epoxy molded Relay Modules are also available.

Each relay contains one or more of these magnetic switches. Mercury-wetted contact surfaces are continually wetted by capillary action; they never bounce, never get dirty, never weld, and never wear out.

Get Bulletin CPC-8 for detailed specifications, characteristics, dimensions: Ask your Clare representative, or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 840 Caledonia Road, Toronto 19, Ontario. Cable address: CLARELAY.

C.P. CLARE & CO.

Relays and Related Control Components

For further information mark No. 23 on Readers' Service Card

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CANADIAN ELECTRONICS ENGINEERING

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- √ Constant low voltage across unknown (9.1v) — no need for voltage coefficient corrections when making high resistance measurements.
- √ Output for 5-ma recorders.

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NEWS HIGHLIGHTS

Dominion Electrohome Industries introduces full-year warranty policy on all its entertainment products

The new warranty, which became effective early in January, applies to the firm's TV sets, TV-radio combinations, hi-fi consoles and car radios, and covers all workmanship and parts with the exception of the record player stylus. "We want to promote the idea of good quality Canadian products and this guarantee backs our intention," stated Electrohome president Carl A. Pollock. Mr. Pollock also said the company would market a color television set in 1961, but would import the chassis from RCA. "The television industry is reaching a saturation point," he said. "I think we will see more and more gadgets and gimmicks being marketed. The industry needs color television as another major step forward." Mr. Pollock also said he thought a major stumbling block to color television in Canada is the problem of the cost to the CBC of establishing a French-language network to offset the English programs that can be imported from the United States.

Ontario Engineering technicians and technologists are moving toward a self-governing organization

This was reported by the certification board for engineering technicians of the Association of Professional Engineers of Ontario at the 39th annual meeting held in Toronto last month. However, the report adds, they will want and need the guidance and leadership of the APEO for some time to come. A prime task of the certification board this year will be to find and train the engineering technicians annd technologists who will be entrusted with the leadership of the new organization, it states.

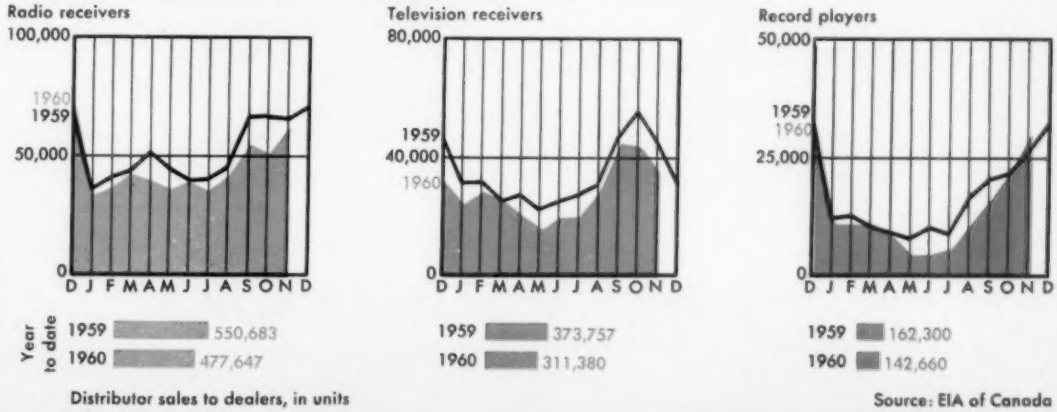
NASA selects Hughes Aircraft Co. to build soft-landing lunar spacecraft

The spacecraft, called Surveyor, will be designed to land gently on the moon, perform chemical analyses of the lunar surface and subsurface and relay back to earth television pictures of lunar features. National Aeronautics and Space Administration plans call for seven Surveyors to be launched to the moon in the period 1963-66. The California Institute of Technology Jet Propulsion Laboratory will provide technical direction for the program, which is expected to cost upward of $50 million.

"Buy Canadian" is no empty slogan at Canadian Admiral Corporation Limited

In introducing three new television models, Ed. Whittaker, vice-president sales of the Port Credit firm, pointed out that 94.7% of the components in a new 23-in. table model were of Canadian manufacture. The percentage rises to 95.0% in a 23-in. console and 95.2% in a 23-in. lowboy model. This high Canadian content is not unusual in Admiral sets, said Mr. Whittaker, since several models in the current television line, introduced last June, are well over 96% Canadian in components. These figures do not include labor cost in the TV sets, which is 100% Canadian.

TV sales off again in November; heading for 330,000 total



Distributor sales to dealers, in units

Source: EIA of Canada

NEW FROM PHILCO

HIGH FREQUENCY NPN SILICON DIFFUSED-BASE TRANSISTORS

30mc PULSE RATE SWITCHES

Type Number	hfe	Typical Power Gain	Typical Switching Times (Saturated Test Circuits)
2N1199	12-60(DC)		tr 35 mμ sec ts 10 mμ sec tf 25 mμ sec
2N1267	6-18	25 db at 4.3 mc	
2N1268	11-36		
2N1269	28-90		
2N1270	6-18	25 db at 12.5 mc	
2N1271	11-36		
2N1272	28-90		

Maximum Vcb—20 V
Maximum temperature—150° C
Maximum dissipation—100 MW

60mc AMPLIFIERS

2N1199

This high speed switch has exceptionally low saturation voltage (typically 0.125 V), permitting *practical* design of 5 mc pulse circuits, using conventional saturated switching configurations. 30 mc pulse rates are obtainable in *practical* circuits using non-saturating techniques.

2N1267-68-69

The high gain characteristics of these units make possible the design of high efficiency IF amplifier circuits for communications equipment. These devices have unusually low collector capacitance . . . typically 1.5 μμf . . . and are available with restricted beta ranges to simplify design problems.

2N1270-71-72

The excellent high frequency response of these transistors makes practical the design of high performance communications systems at frequencies up to 60 mc. They have the same low collector capacitance and are available with restricted beta ranges.

*SADT . . . Trademark Philco Corp. for Surface Alloy Diffused-base Transistor

Philco Corporation of Canada, Don Mills, Ontario

Please send complete information on the SADT type transistors and descriptive brochure of all type transistors available.

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Rogers tube division splits into two separate departments

The Rogers Electronic Tubes and Components Division of Philips Electronics Industries Ltd., Toronto, has been re-oriented into two independent departments, each with a departmental manager reporting directly to the president.

Customers in the field of consumer products will be primarily served by the Entertainment Semiconductor, Tube and Component Department; the manager is **Mr. Peter Bas.** The Professional Semiconductor, Tube and Component Division will have similar responsibilities in the field of professional products, and will be managed by **Mr. Donald S. Simkins, P.Eng.**

Mr. M. C. Patterson, general manager (marketing) of the former Rogers division, has been given a new assignment which will permit the company to benefit from his past experience and background. He will report directly to the president.

Northern Electric appoints J. R. Houghton to telephone contract division, C. B. Woodley to London works.

Mr. Houghton has been appointed vice-president and general manager of the telephone contract division of Northern Electric Company Ltd. A graduate of McGill in mechanical engineering, he joined the company in 1935. He was appointed engineer of manufacture in 1956 and manager of the London works in 1959.

Mr. Houghton is succeeded as manager of the London works by Mr. C. B. Woodley, formerly chief engineer of the communications equipment division.

Canadian Nuclear Association names Roy F. Gross, as general manager.

Mr. Gross graduated in 1935 as a civil engineer from U of T, then joined the RCAF and saw wartime service as a pilot. His postwar service has included periods as Commanding Officer, RCAF station, Summerside, P.E.I.; Senior Air Officer for Newfoundland and Labrador; and in Ottawa at AFHQ from 1953 to 1957. Since that date and prior to his retirement last fall he was attached to the Canadian Embassy in Ankara, Turkey, with the rank of Group Captain.

Mr. Gross is a member of the APEO and of the EIC. He will be located at the association's office in Toronto.

R. N. Fournier has been appointed a vice-president of Canadian General Electric Co. Ltd.

Mr. Fournier is general manager of the company's Wholesale Department, with headquarters in Toronto. He undertook this responsibility in 1958, following key managerial assignments in many of Canada's major marketing areas. Born in Saskatoon, Mr. Fournier joined CGE in 1937 upon graduation from U of S in engineering physics.

Dominion Electrohome appoints B. F. Ellis as advertising manager and K. D. Kerr as manager of new Western Sales Division.

Mr. Ellis will be responsible for co-ordinating all national advertising and promotional programs for the Consumer Electronics Division. After his graduation from U of T in 1952, he joined the Hoover Co. where he was manager of the advertising and sales promotion department before leaving to join Electrohome.

Mr. Kerr will be responsible for the sale of Electrohome products in B. C. and Alberta. The main office of the new sales division will be in Vancouver, with a branch office in Calgary. Mr. Kerr has been advertising manager at Electrohome since 1955 and during the previous three years was Toronto sales supervisor. His experience in the home entertainment and appliance industry dates from his graduation from the University of Western Ontario in 1945.

Fleet Manufacturing Ltd. has appointed A. W. Baker as contract manager.

Mr. Baker was formerly assistant manager and sales manager of Garrett Manufacturing Ltd., Rexdale, Ont.

R. A. Lapetina becomes vice-president—engineering of Edo (Canada) Ltd.

Mr. Lapetina will be responsible for the design and development of military and commercial electronic systems, specializing in the field of sonar and associated underwater acoustics. He is a graduate of Columbia University and spent 12 years with Edo Corp., New York, before becoming chief engineer of the Cornwall, Ont., operation two years ago.

Dr. D. C. Rose, OBE has been appointed associate director of the Division of Pure Physics, National Research Council of Canada.

Dr. Rose will continue to head the cosmic ray section of NRC's Pure Physics Division and to represent Canada on various committees concerned with space research. In addition he will co-ordinate the work on space research in NRC's laboratories with that in other government departments and in universities.

Dr. Rose is chairman of the Associate Committee on Space Research

(Continued on page 56)

Bas

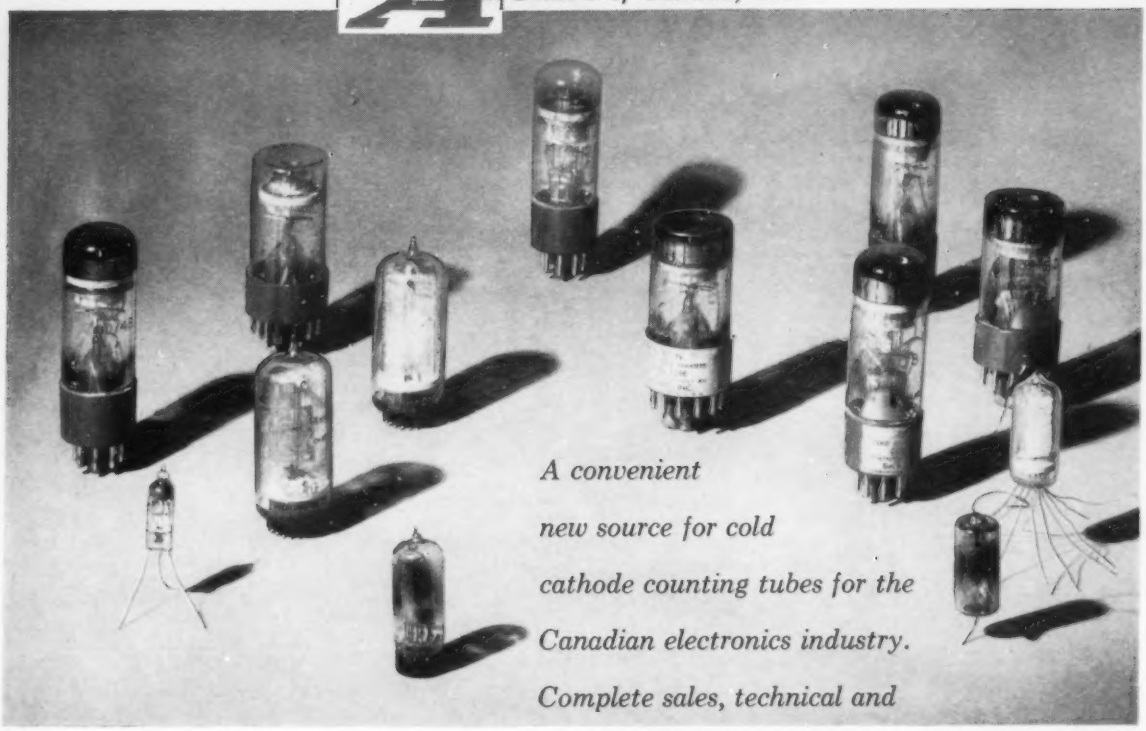
Simkins

Houghton

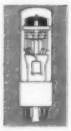
Woodley

Announcing . . .

Baird Atomic *of Canada, Ltd.*



A convenient new source for cold cathode counting tubes for the Canadian electronics industry. Complete sales, technical and warehousing services.



Dekatron Tubes

Full line of nine types for totalizing, sorting, programming or controlling. High speed (up to 20,000 cps). Reliable up to 100,000 hours.

Sign Digitron

Registers the arithmetical operation being followed during random add-subtract counting operations.

Fraction Digitron

Direct readout of the state of count of a ring of four cold-cathode or thermionic tubes. Display: ¼, ½, ¾ and 1.

Miniature Digitron

Ten digit direct readout suitable for miniature remote readout systems. Simple, compact, long life.

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Designed for Dekatron coupling and readout circuits. Reliable in self-quench circuits. Drift-free operation.

Computer Trigger Tube

Inexpensive sub-miniature tubes especially designed for computer application. Widely used for slow-speed storage applications.

Voltage Reference Tube

Useful in high-level stages of DC amplifiers. No jump in characteristic. Constant internal resistance.

Full Size Digitron

Indicates digits 0 through 9. Ideal for remote readout and indicator panel applications.

Write for handbook with valuable information on applications, circuitry and specifications.

Price $1.00

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CGE awarded $1 million contract for air defence search radar

The Canadian General Electric Co. Ltd. is manufacturing approximately $1 million worth of specially-designed electronic equipment as part of the AN/FPS-24 air defence Search Radar contract awarded by the United States Air Force to the General Electric Company.

Under a sub-contract from the U.S. company, the Canadian firm will produce a number of oscillator-drive radar units, designed and built by CGE engineers under a previous development engineering contract.

R. M. Robinson, CGE vice-president and general manager of the company's electronic equipment and tube department, said the units are due to be delivered by April of 1961. Parts of the order are being sub-let to Canadian component manufacturers.

The contract provides an "excellent illustration" of the capabilities of Canadian engineers in developing and producing complex electronic equipment for marketing abroad, Mr. Robinson said.

Philco opens Regina office

The Philco Corp. of Canada Ltd. has announced the opening of a new branch office in Regina, Sask. It will be headed by **William J. Cuff,** well-known throughout western Canadian electronics and appliance merchandising circles. Philco will also introduce a factory service plan for the western customers.

Mel Sales forms new subsidiary

Mel Sales Ltd., Toronto, have announced the formation of a new subsidiary company — MELCOM. The new firm will have the Canadian representation for several major U.S. manufacturers of components for the electronics and allied industries. Offices will be at 1969 Avenue Rd., Toronto 12, and P.O. Box 1352, Postal Stn. "O", Montreal.

Erie to manufacture Grigsby switches

Erie Resistor of Canada Ltd., Trenton, Ont., has concluded a long-term agreement with the Grigsby Co. Inc., Arlington Heights, Ill., to manufacture and market Grigsby high frequency selector switches in Canada.

The Grigsby line includes rotary, lever, slide, push-button and thumbwheel switches, all available in various commercial or military finishes. Special applications may be discussed with the switch engineer at the plant, or the sales engineers at Lake Engineering Co. Ltd., Scarborough, Ont.

U. S. consultants use Toronto computer

A consulting engineering firm in Colorado is using a Toronto installed computer in the design of a hingeless arch in the field of civil engineering. Manufactured in England by Ferranti Ltd., the Pegasus computer is installed at **Ferranti-Packard Electric Ltd.** in Toronto specifically for scientific and engineering applications.

The Colorado firm was able to use one of the $5 million worth of prepared programs available to users of the Pegasus machine.

Tech Associates represents twelve U.S. firms

A new manufacturers' agent was established November 1, 1960 by Mr. E. D. Smith of Tech Reproductions Ltd., Toronto. The company is named Tech Associates and has offices at 23 St. Thomas St., Toronto 5 (Tel: WAlnut 3-8466). In addition to Tech Reproductions Ltd. (engineering and drafting supplies, blueprint and whiteprint papers), the following U.S. firms are represented.

Microwave Development Labs., Inc., Wellesley, Mass. (waveguide components for all bands).

Ferrotec, Inc., Newton, Mass. (microwave ferrite devices, isolators, duplexers, switches, modulators).

Strand Labs., Inc., Newton, Mass. (high-stability microwave signal generator).

Dynatran, Inc., Mineola, N.Y. (transistor test sets).

New England Laminates, Inc., Stamford, Conn. (Nelco copper-clad laminates).

P.C.A. Electronics, Inc., Sepulveda, Calif. (delay lines, miniature pulse transformers).

Microwave Electronics Corp., Palo Alto, Calif. (traveling wave tubes).

Video Instruments Co., Inc., Santa Monica, Calif. (AC and DC amplifiers, power supplies).

Pyrofilm Resistor Co., Inc., Parsippany, N.J. (ultra-high stability sealed resistors).

Ultronix Inc., San Mateo, Calif. (trimming potentiometers, sub-miniature precision resistors, miniature magnetic clutches).

(Continued on page 56)

The Executive Committee of the 1961 IRE Canadian Electronics Conference met in Toronto recently to discuss plans for the October 2-4 event. Seated, from left, are: F. A. Ford, Canadian General Electric Co. Ltd., recording secretary; F. J. Heath, also of CGE, general chairman; A. P. H. Barclay, Philips Electronics Industries Ltd., immediate past-director, IRE Canadian Region; E. L. Palin, Ryerson Institute of Technology, EIA liaison. Standing are: A. R. Low, also of Ryerson, technical program; T. M. Lynd, Canadian Marconi Co., finance; G. G. Armitage, Ferritronics Ltd., social activities; Ross Willmot, public relations and publicity; Grant Smedmor, convention manager; R. A. Turner, Lake Engineering Co. Ltd., Toronto Section IRE, 1959-60; E. Vanderpol, convention office. Other committee members include: B. R. Tupper, B. C. Telephone Co., director, IRE Canadian Region; G. C. Eastwood, Rogers Broadcasting Co. Ltd., exhibits; K. MacKenzie, McCurdy Radio Industries Ltd., Toronto Section IRE, 1960-61; R. C. Poulter, Radio College of Canada, consultant; L. M. Price, Engineering Consultant, registration and reception; T. W. Purdy, Canadian Motorola Electronics Ltd., IRE Canadian Region liaison; L. C. Simmonds, A. C. Simmonds & Sons Ltd., vice-chairman; H. R. Smyth, National Research Council, awards; S. D. Brownlee, Canadian Admiral Corp. Ltd., EIA.

oscilloscope

with all facilities

Important characteristics:

4% calibrated vertical deflection (maximum sensitivity: 50 mV/cm, bandwidth: 0—5 Mc/s)

Optimum trigger stability with manual and automatic level control at repetition frequencies between 10 c/s and 1 Mc/s

Dimensions: 16 x 25 x 34 cm (6.5" x 10" x 13.5")

These three main characteristics make this oscilloscope the standard instrument for service and monitoring applications in industry. It gives just those features you are looking for and which up till now were not available in instruments of this price-class.

Some other data

Vertical amplifier

Bandwidth: 0—5 Mc/s (—3 dB), risetime 70 mμsec
Sensitivity: 50 mV/cm—20 V/cm in 9 calibrated steps (accuracy ± 4%)
Continuous control: 1: 2.5

Time base

Sweepspeeds: 0.5 μsec/cm—30 msec/cm in 7 steps and continuously adjustable

Trigger-possibilities

Internal or from an external source both with pulse repetition frequencies from 10 c/s to 1 Mc/s, as well as from the mains frequency. Stability control and manual or automatic level control.

Horizontal input

Bandwidth: 5 c/s—2 Mc/s
Sensitivity: 3—50 V_{p-p}/cm (continuously adjustable)

C.R.T.

7 cm flat-faced with 1.4 kV accelerating voltage

Probe

Attenuator probe (10: 1) available

timebase voltage of GM 5600 (triggered position)

1 Mc/s damped sine-wave on GM 5600

one line of a TV pattern with vertical bars

instruments: quality ***tools*** for industry and research

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Laboratory technician prepares to make copies of two original drawings on CRONAFLEX Direct Positive Film.

"Cronaflex* speeds up our production cycle, eliminates remakes due to film base failure"

Fred Pierson, Supervisor of Reproduction; Engineering Division of the Otis Elevator Company.

W. Donald Clayton, Du Pont Technical Representative, and Robert H. Pike and Fred W. Pierson of Otis Elevator.

The first successful electric elevator was installed by Otis in 1889. Since then, Otis has pioneered many electrical advances in the elevator industry—all of which require extensive drafting and reproduction of circuit plans. Because of this, its Engineering Division has always been interested in new techniques that improve efficiency of the reproduction operations.

Mr. Pierson explains how Otis is saving time and expense: "We started using CRONAFLEX Direct Positive Film in our shop more than a year ago. The unique durability and flexibility advantages of CRONAR* polyester base have eliminated remakes due to film base failure or damage as well as saving us more than 400 man-hours annually spent in taping film edges before filing. CRONAFLEX also speeds up our production cycle by cutting washing and drying time by 60 to 70%."

Other advantages of CRONAFLEX Direct Positive to Otis Elevator are: it is "virtually indestructible"; it delivers "clear, sharp reproductions with no cracks or creases"; it withstands constant handling and filing; its matte finish does not permit file clerks to become confused, as was the case with clear acetate films, where diagram numbers of underlying sheets were misread as part of the top sheet.

If you work with drawings, there's a CRONAFLEX Engineering Reproduction Film for you. This line is available in four types: (1) Direct Positive Film, (2) Contact Film, (3) Projection Film, and (4) Unsensitized CRONAFLEX. Contact your Du Pont Technical Representative for more information or write: Du Pont of Canada Limited, Photo Products, 85 Eglinton Avenue East, Toronto 12, Ontario.

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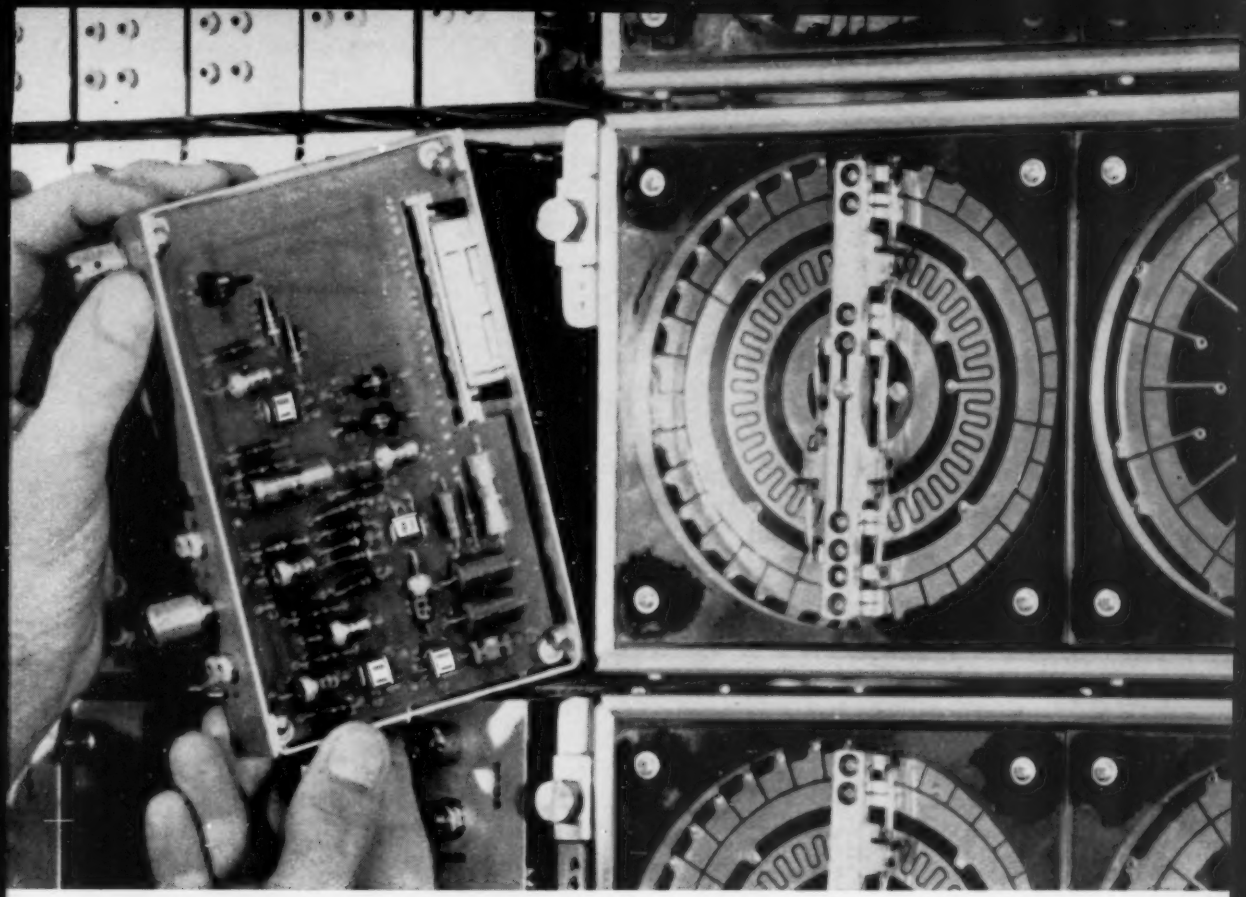


COOK ELECTRIC

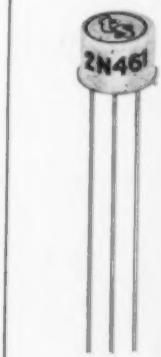
chooses Tung-Sol transistors for automatic air traffic control vocal system

The Cook Electric Automatic Voice Relay is an integral part of a highly advanced system known as Volscan which is designed to relieve the hazards of air traffic congestion over modern airports. The AVR automatically generates flight path instructions vocally to pilots waiting to land, on the basis of data submitted to it by radar. A plane can be brought in every 30 seconds by the system.

Naturally, the highly critical nature of the system's function demanded that components selected to operate in the system meet the highest reliability standards. For this critical amplification and detection circuits in the AVR, Cook specified Tung-Sol transistors. More than 2000 Tung-Sol 2N461 germanium transistors were assigned to these significant tasks. Cook stipulated the reasons for selecting Tung-Sol: "We found that Tung-Sol transistors more than satisfied the high reliability requirements for this operation. Moreover, Tung-Sol was able to meet a rapid delivery schedule."

Why don't you get the benefit of Tung-Sol component knowledge and experience too? Tung-Sol components — whether transistors, tubes or silicon rectifiers — fill virtually every commercial and military application with unexcelled dependability. Tung-Sol applications engineers will be glad to recommend the best components for your design. In Canada: Abbey Electronics, Downsview P.O., Toronto, Ont.

Technical assistance is available through the following sales offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seatle, Wash. Canada: Toronto, Ont.



ts TUNG-SOL®

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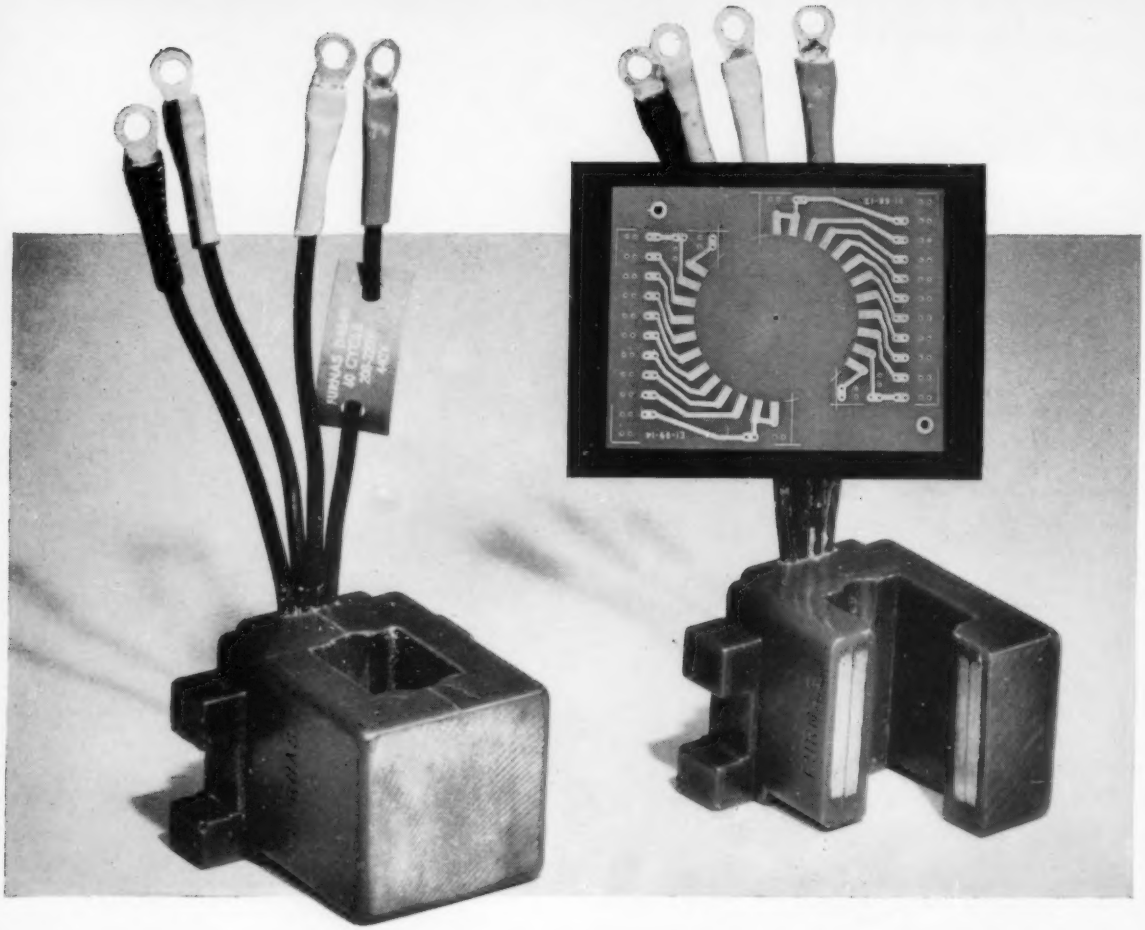


When unusual conditions call for insulation that endures...

THERE IS NOTHING BETTER THAN EPOXIES

Circuit and equipment engineers in electrical and electronic fields are rapidly reaching the same conclusion—that no other type of insulating material now available can provide as many desirable properties as epoxy resins. Here is one high-quality dielectric material that most nearly approaches the ideal sought by designers and users alike.

BAKELITE Brand epoxies have already been proved in many applications. In laminated backings for printed circuits, they combine with glass fiber to give high physical strength along with exceptional resistance to heat, moisture, flame, and chemicals. For encapsulating, the additional advantages of high impact strength, dimensional stability, and excellent dielectric properties have solved many technical problems. Furthermore, epoxies do no shrink during cure—they protect better!

Newer developments—such as in nuclear energy and radiation, missiles and rockets, and underwater exploitation—are creating more demands for superior insulation with the unique combination of properties afforded only by epoxies. If you are stymied by an insulating problem still on your drawing board, let Union Carbide Canada Limited help you find the appropriate solution before it becomes a production handicap. Write Union Carbide Canada Limited, Bakelite Division, 123 Eglinton Ave. East, Toronto 12, Ontario.

EPOXY RESIN INSULATION GIVES YOU SUPERIOR—

HEAT RESISTANCE • MOISTURE RESISTANCE
CHEMICAL RESISTANCE
IMPACT RESISTANCE • FLAME RESISTANCE

"Bakelite" and "Union Carbide" are trade marks.

BAKELITE DIVISION UNION CARBIDE

For further information mark No. 60 on Readers' Service Card

get the size, specs and mobility you need with

SANBORN RECORDERS

2 Channels . . . 35" high mobile cart . . . choice of 4 plug-in preamps

Interchangeable plug-in "850" type preamplifiers in Carrier, DC Coupling, Phase Sensitive Demodulator and Low Level types, for inputs ranging from microvolts to hundreds of volts . internal MOPA available when carrier or chopper excitation is required . . heated stylus, rectangular coordinate recording on 50 mm wide channels . . . transistorized circuits . . . frequency response to 125 cps within 3 db, at 10 mm peak-to-peak. Model 297 can also be used in optional portable case or rack mounted in 10½" of panel space.

Two 50 mm wide channels . . . separate floating input DC amplifiers . . . 4 chart speeds . . . mv or volt inputs

Operate this 1-cubic-foot recorder vertically, horizontally, or tilted at a 20° angle on carrying handle Inputs are floating and guarded . . . 12 sensitivities from 0.5 mv/mm to 20 v/cm . . response DC to 125 cps within 3 db, at 10 div peak-to-peak . : . max. nonlinearity 0.25 mm . . . common mode rejection 140 db min. DC . . . built-in 10 mv calibration signal and electrical limiting . . . internal 1 sec. timer . . . monitor output connectors for each channel. Galvanometers are rugged, low impedance type with velocity feedback damping; most circuitry for each channel is mounted on a single, easily serviced card.

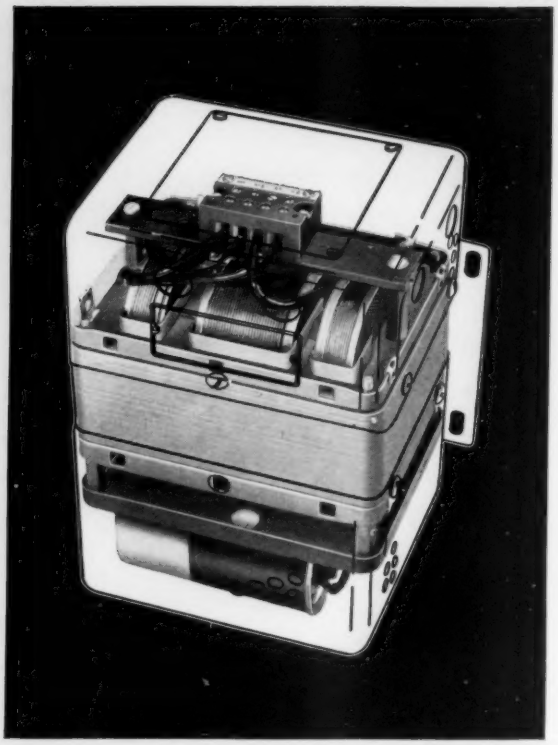
1 Channel . . . 20 lbs., briefcase size . . . 10 mv/div DC Model . . . 10 uv rms/div AC strain gage Model

Extremely compact, highly versatile recorders for general purpose DC inputs (Model 299) and AC strain gage recording (Model 301). Two chart speeds: 5 and 50 mm/sec . . . inkless, rectangular coordinate recording . . . response from DC to 100 cps within 3 db, at 10 div peak-to-peak . . gain stability better than 1% to 50°C and for line voltage variation from 103 to 127 volts Model 299 has balanced to ground input, 10 switch-selected sensitivities, calibrated zero suppression. Model 301 has wide sensitivity ranges, can be used with strain gages and inductive transducers, provides excitation voltage of approximately 4.5 volts rms at 2400 cps, and has uncalibrated zero suppression.

For complete details contact your nearest Sanborn Sales-Engineering representative. Sales representatives are located in major cities throughout the United States, Canada and foreign countries.

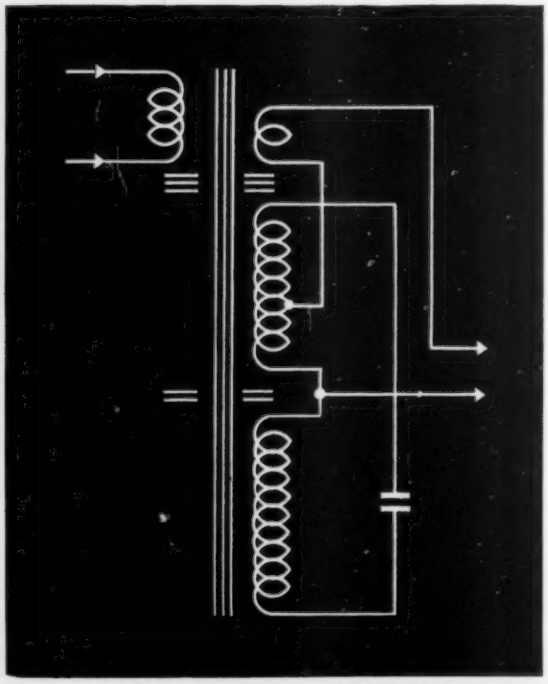
SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

For further information mark No. 49 on Readers' Service Card



Phantom view shows simplicity of Sola design. Note absence of components requiring maintenance such as motors, gears, contactors, tubes and relays.

Schematic diagram indicates the complete reliance on static elements. This is the circuit of a representative Type CVS regulator which delivers output having less than 3% total rms harmonic content.



What's missing in this Sola voltage regulator?

When they designed the Sola Constant Voltage Transformer, what did they leave out? Trouble, for one thing. Original equipment manufacturers and plant engineers know that when you build in simplicity, you build out maintenance headaches.

The two illustrations at the left show clearly the Sola's few parts and straightforward design. This compact simplicity is possible because Sola regulators employ static-magnetic methods of voltage control.

The basic Sola design eliminates moving parts, renewable parts, manual adjustments, routine maintenance, and spare parts stock. Because there is nothing to wear out, no tubes to burn out — you know that when you specify Sola voltage stabilization, you automatically specify trouble-free reliability.

Despite this simplification, the Sola gives you these performance benefits: ±1% regulation over input voltage variations as great as ±15%, response time of 1.5 cycles or less, protection against short circuits for itself and its load, a high degree of isolation between input and output circuits, and negligible external field. Type CVS (illustrated with typical circuit diagram) delivers a commercial sine wave with less than 3% total rms harmonic content.

Sola static-magnetic units are available for regulation of common line voltages, as well as filament, plate-filament, computer-circuit and variable voltage outputs. They can also be supplied in step-up and step-down ratios to replace conventional non-regulating transformers.

Whether you are developing new electric or electronic equipment, or have a specific voltage regulation problem, your nearest Sola sales engineer will be happy to discuss your requirements with you.

Write for Bulletin CV

SOLA

B P
C

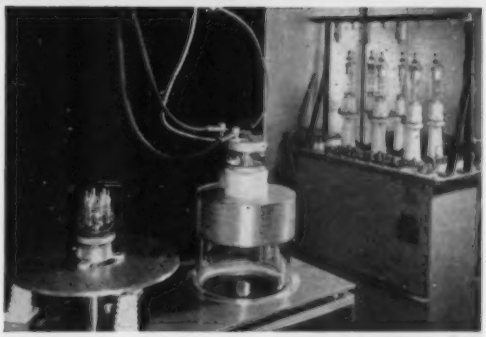
An Affiliate of Basic Products Corporation

SOLA-BASIC PRODUCTS LTD.
377 Evans Ave., Toronto 18, Ont., Clifford 1-1147

For further information mark No. 52 on Readers' Service Card

Marconi Announces

COMPLETE NEW TEST LAB FOR PRE-TESTING SPECIAL PURPOSE TUBES RIGHT HERE IN CANADA



Shown here is the high-voltage power supply —work horse of the new Marconi Test Lab in Toronto. Test facilities are available for testing either air, water or vapour-cooled high-power electron tubes up to 200 kw. with static power of 25 kw.

The Lab tests all Special Purpose Tubes for manufacturing defects, or for damage caused in storage or in shipping from the manufacturer. At left, an oscilloscope takes pulse measurements of a BR1102 Tube. Tests are made under simulated operating conditions. Every detail is carefully checked before tubes are shipped...sealed and protected by the Marconi warranty.

Now, annoying lengthy delays and inconveniences caused by faulty Special Purpose Tubes are the thing of the past. No longer need you wait—and *wait*—while these tubes are sent back to the manufacturer—often in the U.S. or Europe—for repair or adjustment.

For Canadian Marconi's new Special Purpose Tube Test Lab, only one of its kind in Canada, is centrally located in Toronto for faster customer service. All tubes are fully tested in the lab before they are shipped out to you. This guards against the possibility of your getting a defective tube. Should any trouble occur on a Marconi Tube, you can be sure of immediate warranty adjustment.

And Marconi experience stands behind Marconi service! Should you have any problems regarding your Special Purpose Tube, a Marconi electronics specialist will be glad to help you out. Just give us a call.

ELECTRONIC TUBE AND COMPONENTS DIVISION

CANADIAN **Marconi** COMPANY

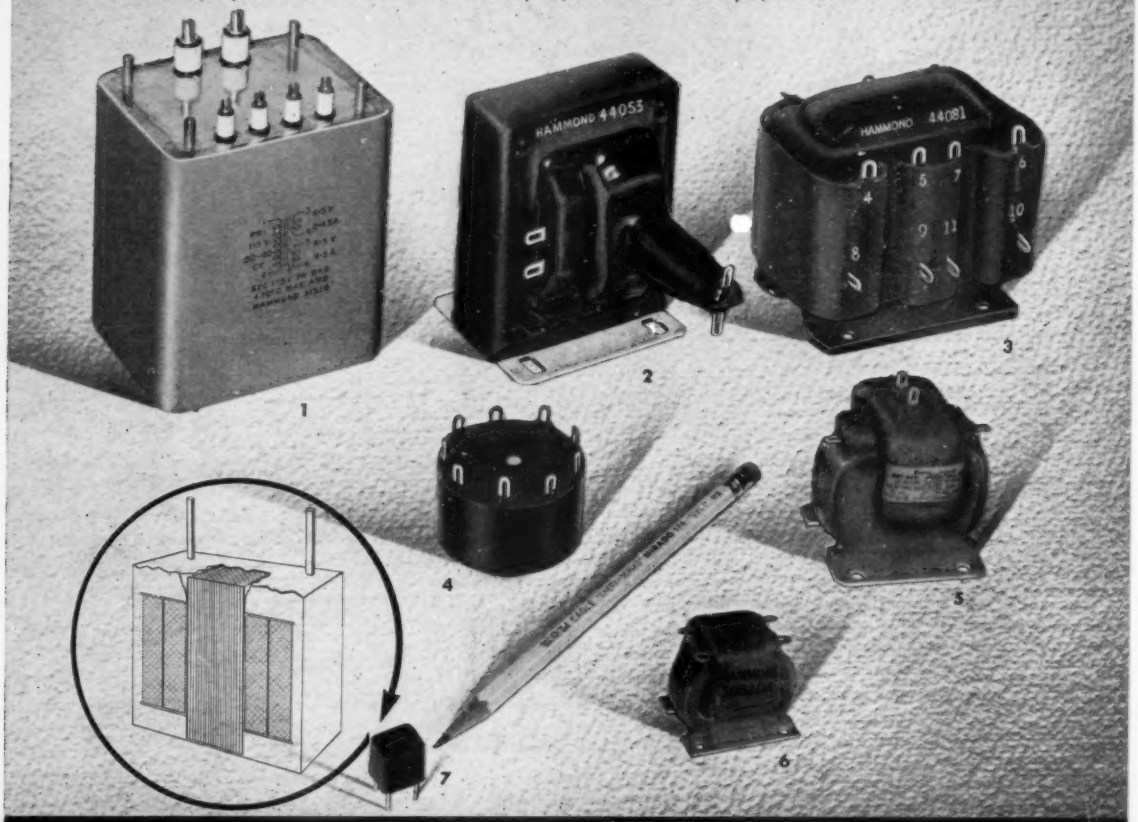
1830 BAYVIEW AVENUE, TORONTO, ONTARIO

Branches: Vancouver • Winnipeg • Montreal • Halifax

For further information mark No. 21 on Readers' Service Card

HAMMOND Epoxy — Protected Transformers

1. Epoxy Filled, Metal Cased, Hermetically Sealed Power Transformer. Primary 115 v, 50-60 cycles. Secondary #1 6.5 v., 0.45 amp. Secondary #2 6.5 v., 9.5 amp.
2. Epoxy Encapsulated, High Voltage Filament Transformer. Primary 117 v., 50-63 c.p.s. Secondary 36 v., 0.5 amp. (18,000 volts R.M.S. Test).
3. Encapsulated 3 Phase 400 c.p.s. 675 va., 6 Phase Rectifier Transformer.
4. Cast Epoxy Toroid Transformer for transistorized power supply.
5. Epoxy Encapsulated, Low Capacity High Voltage Pulse Transformer. Primary 10 ohms, 20 . . . Sec., 10 kv. peak working. Secondary 75 ohms.
6. Epoxy Encapsulated Isolating Transformer. Primary 115 v., 380 to 420 cycles. Secondary 115 v., 0.15 amp.
7. Cast Epoxy Sub-miniature Transformer. Primary 20,000 ohms. Secondary 5,000 ohms.



High Performance Lightweight Transformers

FOR MILITARY AND OTHER EXACTING REQUIREMENTS!

Hammond Cast, Potted and Epoxy Encapsulated Transformers utilize a Hammond developed, modified epoxy resin with "vacuum cycle" application. In impregnating the transformer original insulation is improved and efficiency increased.

Hammond Epoxy-Protected Transformers have exceptional resistance to moisture, contaminants, temperature variation and physical shock. They should be considered wherever lightweight and high performance are essential, and as a possible alternative to hermetically sealed construction.

HAMMOND

EPOXY INSULATED TRANSFORMERS

Canada's leading jobbers stock Hammond Transformers.

HAMMOND MANUFACTURING COMPANY LIMITED • GUELPH, ONTARIO, CANADA

For further information mark No. 32 on Readers' Service Card

a new family of light-route radio systems by *Lenkurt*

The new Lenkurt Type 71 light-route radio equipment is available for operation in the 150 mc, 450 mc and 900 mc bands. It provides toll-quality transmission of up to thirty multiplexed voice channels over distances of up to ten hops. Greater channel capacity can be obtained over shorter distances.

Designed for high-reliability service, the 71 utilizes proven circuit techniques, and rugged long-life tube types. The transmitter, receiver and power supply are in one compact unit requiring only 17½ inches of rack space. The front panel of the terminal hinges out to provide front access to all components.

Built-in metering facilities permit complete in-service performance testing and maintenance checks.

Transmitter power output and receiver noise alarms are provided including both local indication and facilities for connection to remote equipment.

Automatic transfer panels and combiners are available for applications requiring diversity operating standby, or hot standby systems. Service channel equipment including order-wire and supervisory units, is also available.

This new Lenkurt light-route radio equipment was designed and manufactured in Canada.

For complete information call or write: Lenkurt Electric Co. of Canada Ltd., 7018 Lougheed Highway, N. Burnaby P.O., Vancouver, B.C.

L6102

LENKURT ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

For further information mark No. 37 on Readers' Service Card

MODEL 119 D.C.
MODEL 120 A.C.

Bach Simpson
TEST EQUIPMENT

for:
EDUCATIONAL
INDUSTRIAL
and SCIENTIFIC
APPLICATIONS

MODEL 19 D.C.
MODEL 20 A.C.

MODEL 9 D.C.
MODEL 10 A.C.

MODEL PP1 D.C.
MODEL PP2 A.C.

A wide range of standard Testers, from hand-sized portables of standard 2% accuracy to ½% bench and portable standards is in regular production. Special and multi-range instruments are available in addition to the standard types listed in our catalogue C14A.

Bach-Simpson
LIMITED
1255 Brydges St., London

K2198

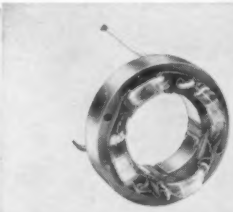
For further information mark No. 16 on Readers' Service Card

the new generation of

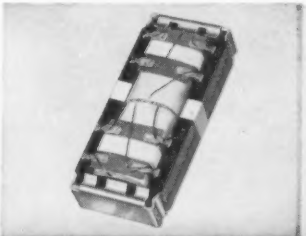
MAGNET WIRES

It could be that there is a *better* type of magnet wire available for your use today, than the type now being used. Modern technology has created an impressive number of new types of magnet wires. Canada Wire is making *all* types, so Canada Wire is best equipped to advise you. Call your nearest Canada Wire sales office and discuss your problem. The result could be profitable for you.

FORMEL
The best general purpose magnet wire now being manufactured. It is a vinyl acetal coated wire that has many outstanding properties for use in equipment functioning at temperatures not exceeding 105°C.



Fan Motor Stator Winding



Fluorescent Lamp Ballast Transformer Coil

NYLON
A polamide coating wire characterized by excellent windability and ability to solder in dip operations at temperatures of 650°F. to 750°F. without prior removal of coating.

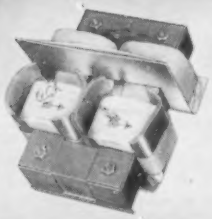
BONDEL
A Formel insulated wire with a thermoplastic cement overcoat. This overcoat softens when exposed to heat (275°F.) or solvent (alcohol). Will bond the wires in a desired shape on cooling.

Deflection Yoke Coil for Television

Electronic IF Transformer Coil

POLYSOL
A modified isocyanate coated wire characterized by its excellent electrical properties (particularly at high frequencies) and its ability to solder in dip operations without prior removal of the insulation.

PLAIN ENAMEL C-90
Insulated with an oil resin varnish film. Provides outstanding electrical properties in very thin film build-ups.



Oil Burner Ignition Coil

Automotive Generator Armature

POLYSOL-N
Polysol insulated with a nylon overcoat. Combines the excellent windability and solvent resistance of nylon with the outstanding electrical characteristics of polysol. For soldering in dip operations without prior removal of coating.

QUALITY CABLE IS LOW COST CABLE

Canada Wire and Cable Company Limited

MAGNET WIRE DIVISION—SIMCOE, ONTARIO

A Canadian Company Manufacturing and Selling Coast to Coast

60-61

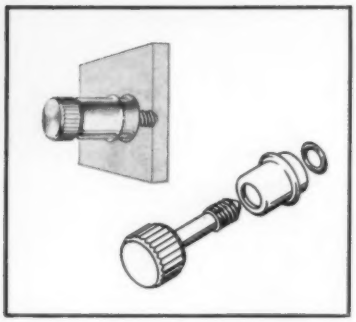
TRADE MARK REGISTERED

For further information mark No. 63 on Readers' Service Card

Compact Captive Panel Screws:

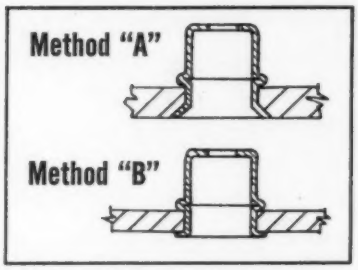
Standard Design Lowers Installed Costs

No longer is it necessary to resort to a costly fastening device of special design to provide quick attachment and release of electronic components. Standard Southco Retractable Screw Fasteners (stand-off thumb screws), available from stock, are both fast to install and economical. The five sizes,

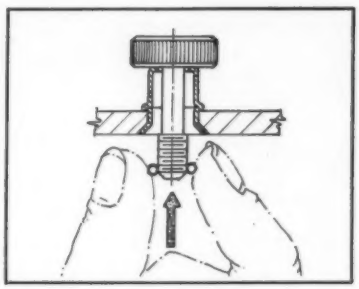


shown below, meet a very wide variety of requirements.

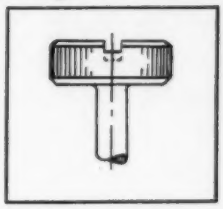
Check these advantages of simplified Southco Captive Panel Screws. Even when many screws are in one panel, misalignment is easily handled because the screw floats in a large hole in the stand-off, allowing ample play for "lining up." No special tools are



needed for installation, thus production is not subject to tool failure, nor limited by either the number of special tools available or the number of personnel trained in their use.



The Southco No. 58 Retractable Screw Fastener consists of three parts: thumb screw, stand-off, and retaining ring. The bright nickel-plated brass stand-off is inserted in either a drilled and countersunk hole (Method A), or a drilled hole (Method B), and flared. The polished, chrome-finished brass screw is passed through the hole in the stand-off and made captive by a retaining ring. Engaging in a tapped hole in the frame, the screw may be fully withdrawn without moving the panel, yet always is retained.



The unslotted screw is standard in 3/4", 9/16", and 7/16" head diameters and three thread sizes. Slotted head screws are also available in all sizes. The stand-off is standard in sizes to fit panel thicknesses from a minimum of 1/16" to a maximum of 17/64". Screw and stand-off are also obtainable in stainless steel.

MINIATURE TO LARGE SIZE HEADS IN FIVE TYPES

HEAD DIAMETER	3/4"	9/16"	9/16"	7/16"	7/16"
THREAD SIZE	1/4-20	1/4-20	12-24	10-24	10-32

Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Write to your nearest distributor listed below.

Represented in Canada by . . .

METAL AND WOOD FASTENING DEVICES
6302 Papineau Avenue
Montreal 35, Quebec

BLACK BROTHERS, LTD.
1200 Hornby Street
Vancouver, B.C.

WESTAIR SALES CO.
380 Donald Street
Winnipeg 1, Manitoba

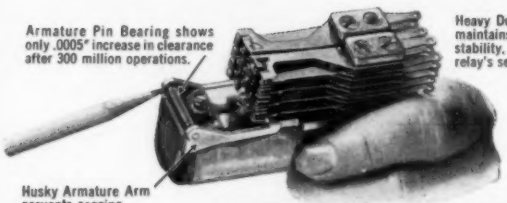
METAL AND WOOD FASTENING DEVICES
301 King Street, East,
Toronto, Ontario

SOUTHCO FASTENERS LION

For further information mark No. 53 on Readers' Service Card

HERE'S WHY P&B TELEPHONE TYPE RELAYS GIVE YOU

reliable performance over long life



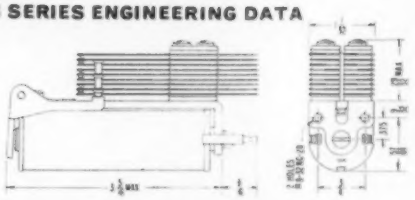
BS SERIES TELEPHONE TYPE

Measure the thickness of the BS series armature arm. You will find the cross section area is greater than ordinary relays of this type. Here is the kind of quality that spells dependability.

Observe that the stainless steel hinge pin runs the full width (not just half) of the armature, providing optimum bearing surface. This pin, operating in a stainless steel sleeve, shows only minimal wear during nearly a *third of a billion operations.*

Best of all, P&B quality costs no more. A whole new plant is being devoted to the production of high performance telephone type relays. Your nearest P&B sales engineer will be happy to discuss your relay problems. Call him today.

BS SERIES ENGINEERING DATA



GENERAL:
Breakdown Voltage: 1000 volts rms 60 cy. min. between all elements.
Ambient Temperature: −55° to +85° C. +125° C available on special order.
Weight: 9 to 16 ozs.
Terminals: Pierced solder lugs; Coil: One #16 AWG wire Contacts: Two #18 AWG wires
Enclosures: Dust covered or sealed

CONTACTS:
Arrangements: DC—up to 28 springs AC—up to 24 springs
Material: 1/16" dia. twin palladium. Up to 1/4" dia. single silver. Other materials on special order.
Load: 4 amps at 115 volts, 60 cycle resistive
Pressure: 15 grams minimum

COILS:
Resistance: 100,000 ohms maximum
Current: 10 amps maximum
Power: DC—50 Milliwatts per movable arm. Greater sensitivity on special order. AC—17.9 volt-amps.
Duty: Continuous
Treatment: Centrifugal impregnation
Voltages: DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

MOUNTING: Two #8-32 tapped holes 3/4" o.c. Other mountings on special order.

GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.

LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.

TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD CANADA LTD.

GUELPH, ONTARIO

For further information mark No. 45 on Readers' Service Card

(ACTUAL SIZE)

NEW "BOUNCE-FREE" SWITCH

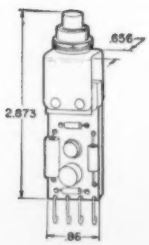
Eliminates Contact Bounce in High-Speed Electronic Applications

A new compact switch device has been developed by MICRO SWITCH to eliminate the effects of contact bounce in applications which involve high speed electronic tubes that operate in less than a microsecond.

This new "Bounce-Free" Switch makes it possible for designers to save valuable engineering time otherwise required to develop special circuits to eliminate spurious voltage pulses caused by contact bounce. And, its compactness makes it possible to save valuable cabinet space in control consoles.

The new circuit may be actuated by any switch that has a normally open and normally closed position. It is an electronic switch triggered by a mechanical switch.

Write for Data Sheet 177 which describes the new "1PB2000." Honeywell Controls Limited, *Precision Components Division*, Toronto 17, Ontario.



Honeywell
MICRO SWITCH Precision Switches

OPERATING CHARACTERISTICS

There are four circuit types available. One produces a positive output to accommodate resistive loads of 100 to 500 ohms, another produces a positive output for resistive loads of 500 ohms or greater, and two produce a negative output voltage at these loads. All circuit types have a voltage range of from 5 volts to 25 volts.

The circuits are designed to produce an output voltage which has a maximum rise time of ½ microsecond.

For further information mark No. 34 on Readers' Service Card

fills the chair when no one's there

Now ELECTRONIC SECRETARY offers a full range of automatic answering sets opening a broader market for these profitable machines. The brand new transistorized long-play model, shown above, will answer the phone 24 hours a day, seven days a week—ideal for the small business man or professional man who must leave his phone unattended, yet relies on his phone for business. And it's great for large companies too. It is suitable for taking long or short messages, sales orders and reports, absentee reports, employee suggestions, or for giving messages and delivering announcements. All this at a low monthly rental. ● Other basic ELECTRONIC SECRETARY models, at lower rentals, are the Short Play and Answer Only models. The Short Play will answer and receive 12 short messages; the Answer Only unit will answer and deliver a message up to three minutes in length. ELECTRONIC SECRETARY is only one of a vast range of telephone products sold by AUTOMATIC ELECTRIC, a company known all across Canada for best quality products, and fast, efficient after-sale-service. For full information write Automatic Electric Sales (Canada) Limited, 185 Bartley Drive, Toronto 16, Ont. Branches across Canada.

*New line of ELECTRONIC SECRETARY telephone answering sets

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

For further information mark No. 13 on Readers' Service Card

Going Dial?

AUTOMATIC ELECTRIC *service* makes the difference

When you're converting to dial, Strowger C.A.X. equipment is your logical choice—a vital step to larger revenues and faster growth. Manufactured to North American telephone standards, it is *custom built* to your requirements, and assures vastly improved service for your subscribers.

Economical, reliable Strowger C.A.X. equipment incorporates all the latest advances in design and quality construction. It provides ready expansion with simple jack-in equipment—unusually low maintenance, and very fast call tracing—plus many optional features such as automatic time announcing and weather reporting.

In addition, Strowger C.A.X. equipment is readily adaptable to SATT—famous Strowger Automatic Toll Ticketing equipment that handles complex and costly toll ticketing problems *automatically—and economically*.

To convert to dial with Strowger C.A.X. equipment simply call Automatic Electric—and a highly trained equipment engineer will take over from there. From initial planning and layout of buildings, to selection, supply and installation of every item of equipment, Automatic Electric will handle the entire project.

Strowger C.A.X. keeps pace with your changing needs, however fast your community grows. For full information write Automatic Electric Sales (Canada) Limited, 185 Bartley Drive, Toronto 16, Ont. Branches across Canada.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

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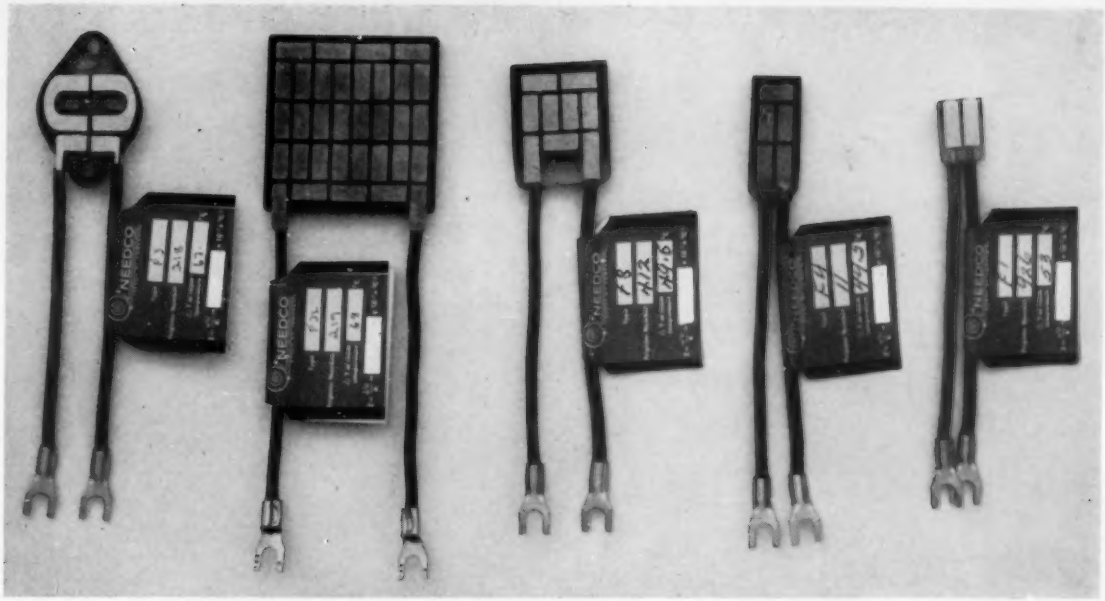

Typical range of Frigistor thermoelectric devices showing variety of configurations and sizes.

Semiconductor materials provide key to thermoelectric developments

ROMAN POST POSLAWSKI, MEM. AIME*

Recent developments in semiconductors have made it feasible to produce thermoelectric devices which can compete commercially with small compressor-type cooling units. Research is opening up new market prospects for such devices. Surveys show that supply of raw materials can keep up with demand.

Thermoelectricity, or the science of direct conversion of heat into electricity, and the use of electricity to effect heat pumping, is based on principles discovered more than a hundred years ago. Yet only the last decade witnessed development that brought us closer to commercial use of the phenomena. Today, we have entered the thermoelectric age in which solid state devices will replace conventional methods of cooling, heating and power generation.

Contemporary work on thermoelectric materials was started by Professor Ioffe in 1920. This eminent physicist devoted most of his life to the study of the physics of solids. Born in 1880, A. F. Ioffe completed his studies at the St. Petersburg Technological Institute, and then did research work under Professor Roentgen at Munich University. He organized most of the physical research in Russia in the period between the two wars, including research on semiconductors. After the end of the Second World War, Ioffe devoted himself almost entirely to the study of semiconductors and was, until his death in October 1960, the Director of the Institute for Semiconductors of the U.S.S.R. Academy of Sciences.

His work, "Semiconductor Thermoelements and Thermoelectric Cooling", translated by A. Gelbtuch, Infosearch Ltd., London, is quoted by C. Zener as "the Bible of those working in the field of thermoelectricity".

His next work, "Physics of Semiconductors", edited in December 1960 by Mr. Gelbtuch, will be available shortly, and gives a very complete picture of the status of art in this field.

Fundamental research in the field of cooling semiconductors has resulted in a complete program of development of industrial and commercial applications of thermoelectric devices. Mr. Gelbtuch was assistant to Professor Ioffe during the Second World War, and after his escape from Russia, organized systematic work on the improvement of materials and their commercial applications. As mentioned previously, Ioffe's work has been translated and edited, and as a result, similar research has been started in the laboratories of several of the larger American corporations. Progress in this field is rapid, and it seems that the Western World can now afford to be proud of its several outstanding results. A large part of the credit should go to the U. S. Navy—Bureau of Ships—which sponsored a large research program in this field.

A fundamental research program, as well as application and engineering, has been organized by Needco Group of Companies, with a research laboratory in London, headed by Mr. Gelbtuch. The prominent English

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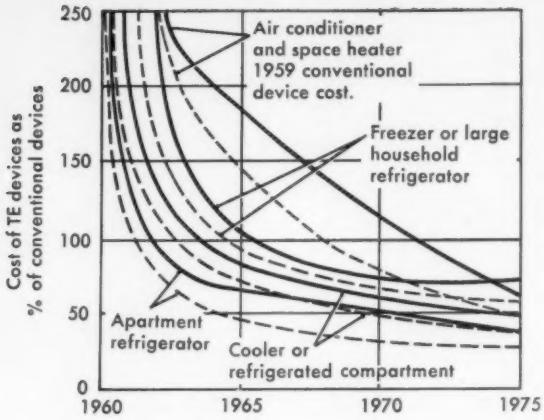


scientist, Professor Dr. J. R. Drabble, from the University of Exeter, previously head of the Solid State Group, General Electric, London, joined the London group on January 1 this year. In Montreal the main research laboratory is headed by Mr. C. A. A. MacPhee. The laboratory co-operates closely with the production plant and metallurgical plant, occupying a total of 75,000 sq. ft. In Princeton, N.J., the group owns a subsidiary, General Thermoelectric Corporation — an Applications Department and future assembly plant.

Needco Group of Companies announced on January 12 that its thermoelectric material, Neelium, a quaternary alloy of bismuth, tellurium, selenium and antimony, has been improved up to optimum requirements suitable for military, industrial and commercial applications. Thermoelectric modules made out of Neelium are marketed under the name "Frigistors" and have a ΔT of up to 77.8 deg. C with the hot junction T_h at 27 C and the cold junction T_c at —50.5 C. These results are for P-type material prepared by powder metallurgy technique and N-type material by zone-melting method. Frigistors are also available with both P and N branches made by powder metallurgy or zone-melting techniques. This material has been produced at our Montreal plant and can be regarded as a particular success in Canadian technology. This is believed to be the highest ΔT achieved in thermoelectrical materials throughout the world, based on Western World as well as Russian releases.

PRACTICAL APPLICATIONS

Thermoelectricity is ready for application in the following fields for cooling and power generation.

Military

Prospects for military applications are excellent. Examples are air-conditioning system for submarines (where elimination of moving parts reduces danger of detection through noise), cooling for life support system for satellites, space kitchen, portable blood plasma refrigerator and blood heat exchanger. Availability of material is good.

Instrumentation

Application prospects are excellent and availability of material is rated as good to excellent. Examples are ice reference junctions, spot coolers, freezing of microtome table, pencil cooler, laboratory cooler and cooler for electron microscope.

Industrial

Application and availability are good. High vacuum baffle traps, container for epoxy resin (giving long pot life), gas and liquid cooler for production processes are examples.

Appliances

Application possibilities are excellent for small size, fair for medium size and poor for large size heat pumping devices competing directly with compressor systems. It is believed that Needco Group of Companies is ahead of the predicted schedule for practical applications. On the graph, solid lines represent cost estimates prepared by several U. S. research institutes. Dotted lines represent the predicted status for Needco Group of Companies.

Examples of appliances are freezers and air-conditioners for aircraft, yachts and cars; vending machines; hot and cold storage cabinets for home and office.

Feasibility of production

Until recently, zone melting techniques were used for production of thermoelectric materials, but there were a number of problems leading to high production costs. Now, Needco Cooling Semiconductors Ltd. has introduced Neelium, made by sintering techniques, which has excellent shock and vibration resistance, uniformity from batch-to-batch, good plating and soldering contact acceptability, and good prospects for reduced production costs.

These are the properties of Neelium:

	P-type	N-type
Average Seebeck coefficient	190 uv/deg. C	210 uv/deg. C
Average resistivity	1.1×10^{-3} ohm cm	1.25×10^{-3} ohm cm
Average effective Z-value*	2.6 to 3.0×10^{-3} per deg. C	

*For an unencapsulated couple measured in vacuum at $T_h = 300$ deg. K.

Supply of raw materials

According to the U. S. Department of Interior, Bureau of Mines, the production of primary domestic tellurium was estimated at 300,000 lb. in 1959, and somewhat higher for 1960. According to experts in the industry, production in the U. S., Canada and other Western countries can be increased to approximately 1,000,000 lb. per year. A study conducted by Needco Group of Companies lead to more optimistic figures, particularly since the U. S. Bureau of Mines has announced a new and intensive research program to locate new sources of tellurium.

However, using the figure of 1,000,000 lb. per year, we can figure how many couples can be made in a year. So far, standard couples made in the U. S. have had P and N branches of 6.2x6.2x7 mm, or round rods with diameters of 7, 9, 11, 12½ or larger, up to 38 mm. Needco's P and N branches are only 4x4x4 mm. and weigh 0.6 grams for each couple. In other words, with 1,000,000 lb. of tellurium a year, 760,000,000 couples can be manufactured. This, of course, assumes that 100% of the material used in the production of thermocouples is tellurium, but it isn't. Needco's neelium alloy contains only approximately 50% tellurium, the balance being made up of bismuth, selenium and antimony which are in plentiful supply. Therefore, with 1,000,000 lb. of tellurium a year, approximately 1,520,000,000 couples could be manufactured annually.

Needco could change its standard P and N block size to 4x2x2 mm, which would use only a quarter the amount of material. On this basis, 6,080,000,000 couples per year could be produced. Assuming that at some future date the cost of a couple reduces to 10c, this could represent a sales volume of approximately $608,000,000 for the entire industry.

Rapid development can be expected

Outstanding work has been made by several workers in the field of thermoelectricity which will result in rapid developments in the near future. Professor Ioffe and his co-workers have outlined a basic theory of energy transport in semiconductors.

A system of measurement has been systematically worked out by H. J. Goldsmid, T. C. Harman of Battelle Institute, and Needco workers, C. A. A. MacPhee, John H. Ashby and W. Heilmann. Work on intermetallic connection has been developed by Dr. Maria Telkes. Work on ternary and quaternary alloys has been carried out by H. J. Goldsmid and Needco workers such as A. R. Sheard, John H. Ashby and C. A. A. MacPhee. Several interesting theories have been outlined, e.g. the development of alloys in the operating range close to the melting point. A large contribution was made by Professor J. R. Drabble, toward the better understanding of the principles of energy transport in semiconductor alloys for cooling and power generation. The path for future development has been defined, and can be strictly followed. No practical limit to the figure of merit has yet been set.

Are thermoelectric devices ready for marketing?

The engineering of thermoelectric devices is sufficiently developed to justify marketing of these devices. The first difficulties have been overcome, and the work is progressing satisfactorily. On the other hand, a lot of effort will be necessary in the near future in order to render these devices competitive, particularly in large quantities, with the present mechanical cooling system. It is a rather common saying that physicists call engineers "plumbers". Still I think that everybody will agree now that the role of engineers in the practical development of thermoelectric devices is very important, and even the best material cannot be used for practical purposes if the heat transfer hardware is not properly engineered. The material has to be enclosed in a rigid form for easy assembly in working devices. The heat transfer surface should be ground and lapped, to ensure the best heat transfer to heat sink and cold fin. Several systems have been evaluated and problems have been solved, particularly during the development of a large unit for submarine air-conditioning. Several patents for the assembly of thermoelectric materials, building of the metallic junction and for low resistance connection of junction to materials have been filed by Needco Group of Companies and other workers. In general, the low resistance connections have been improved to such an extent that it is difficult to measure the value.

Engineering work is being concentrated now on mass production techniques, which can facilitate the production of modules and devices at competitive prices. The general philosophy of the Needco design is standardization. Several selected sizes of modules (Frigistors) have been picked and engineered. (The following sizes are selected as privileged: F-1, F-2, F-3, F-4, F-8 and F-32.) These Frigistors have been presented to several large American corporations in the field of instrumentation, appliances, and special applications. It is believed that if several customers can standardize sizes, the quantity can be increased to such an extent that the cost will become attractive to the commercial market.

Work is being carried out on the solution of standard problems. The following prototypes can be considered as examples of the work in progress: Co-current, cross-current and contra-current heat exchangers.

The devices are going to be built in the practical form of air-to-air, air-to-water, water-to-air, and water-to-water modules.

(Continued on page 39)

News on recent developments in the field of thermoelectric devices was presented at the Joint Technical Society-Department of Defense Symposium on Thermoelectric Energy Conversion held in Dallas, Texas, Jan. 8-12, 1961. Papers were presented on improvement of materials for cooling and power generation, improvement in measurement and the system of computing parameters of materials and devices, and about the engineering of devices for practical application. The following titles indicate the range of information presented.

Thermoelectric properties of the Bi_2Te_3-Bi_2Se_3 isomorphic compound system. The formation of ternary semiconducting alloys. The synthesis, structure and thermoelectric properties of some II-IV compounds. Synthesis and properties of the samarium sulfides. Measurement of thermal conductivities of liquid thermoelectric materials from 1000 to 1800 deg. C. The NRL thermal conductivity apparatus and reproducibility of t vs t_{mean}—characteristics obtained with the comparator. Contact resistance studies on thermoelectric materials. A vacuum test device for the measurement of thermoelectric material properties. Exact computer solution of segmented thermoelectric devices. Solutions to the differential equations describing the temperature distribution and thermal efficiency of a thermoelectric element with variable properties and cross-sectional area. Thermoelectric air conditioner for submarines. Construction and experimental evaluation of a thermoelectric air-to-water heat exchanger. Construction and evaluation of a thermoelectric-controlled temperature chamber.

MARKET PROJECTION FOR THERMOELECTRIC MATERIALS AND DEVICES IN CANADA - U. S.

	1961		1962		1963		1964		1965	
	*	$M	*	$M	*	$M	*	$M	*	$M
Neelium and other material	35%	1.5	30%	4	25%	8	20%	16	12%	32
Family of spot coolers....	30%	2	30%	6	20%	15	15%	25	7%	60
F-32	100%	.250	50%	1	30%	2	15%	3.5	7%	5
Applications kits	100%	.300	100%	.200	100%	.100	100%	.100	100%	.100
Industrial market baffles...	100%	.100	50%	1	15%	5	8%	15	6%	25
Lab. instn. & scientific mkt.	100%	.500	50%	2	20%	5	10%	15	7%	25
Estimated sales for Needco	$ 2,275,000		$ 5,200,000		$ 7,450,000		$10,275,000		$ 11,750,000	
Estimated total market ...	$ 4,650,000		$14,200,000		$35,100,000		$74,600,000		$147,100,000	

* Needco Group estimated share of the market.

Design curves aid proper utilization of thermoelectric devices

A. GELBTUCH & C. A. A. MACPHEE*

Diagrams are given from which the performance data of Frigistors under various conditions can be obtained. Their use is illustrated by two examples: a refrigerated box and a vacuum pump baffle.

At the inception of the Needco Company, it was realized that materials and devices at least equal to those expected to be available from the rest of the industry would be necessary for successful competition. The Frigistor diagram (Fig. 1) was drawn up to show the characteristics of thermocouples prepared from Neelium materials having a combined figure of merit of 2.6×10^{-3}. No allowance was made for the effect of junction resistance in the calculations involved, thus any device which has the performance indicated in the diagram must have a figure of merit somewhat higher than 2.6×10^{-3}.

Measurements performed on representative couples in the laboratory showed that material made from September 1960 onwards could be used to produce thermocouples whose performance was in substantial agreement with the Frigistor diagram. The current at which $\Delta T_{max} = 70°C$ at $T_h = 30°C$ was slightly lower than predicted, due to the combined effects of contact resistance and non linear temperature distribution in the blocks but the value at ΔT_{max} predicted was obtained.

Improved materials have now been developed, which give ΔT_{max} of 72–74°C; a description of the work involved has been given in another article in this series.

The diagram contains three sets of curves plotted in a rectangular grid of temperature (marked on the left) and current values (marked at the top). The solid 'Q_c' lines extending from left to right give the cold junction temperature T_c for a given hot junction temperature, T_h, at the constant cold junction heat loads Q_c. It should be noted that T_h and T_c are junction temperatures, not hot and cold ambient temperatures. The differences between the junction and ambient temperatures depend on the overall junction-to-ambient heat transfer coefficients.

To enable this diagram to be used for different values of T_h and different numbers of couples, the curves are numbered on the right from Q_{-5} to Q_{30}. The curves are plotted at $1W$ intervals for an F-8 Frigistor, $\frac{1}{2}W$ for an F-4 Frigistor, $\frac{1}{4}W$ for an F-2 Frigistor, and $\frac{1}{8}W$ for an F-1 Frigistor (single couple). For example, for a hot junction temperature $T_h = 50°C$, the curve Q_5 gives the cold junction temperature, T_c, at zero heat load (insulated cold junction), the curve Q_6 gives T_c at $Q_c = 1W$ (for F-8 Frigistor), the curve Q_{10} gives T_c at $Q_c = 5W$, etc. Similarly, for $T_h = 100°C$, the curve Q_{10} gives T_c at $Q_c = 0$, etc. It will be noted that on each curve I_c reaches a minimum at a certain value of the current, I_Q; the same current gives the maximum heat pumping rate for the given value of T_c. For every T_h and T_c there is a value of current at which the coefficient of performance (ratio of the heat load, Q_c, to the power consumption of the Frigistor, W) is maximum. The maximum coefficient of performance is infinity at zero current and is zero for maximum junction temperature difference (when $Q_c = 0$). The dashed lines on the diagram show the current, I_ϕ, for maximum coefficient of performance, ϕ_{max}, for T_h from $-50°$ to $+200°C$ and different values of $\Delta T = T_h - T_c$. Since the maximum coefficient of performance assumes on the lines all values from zero at ΔT = max to infinity at $\Delta T = 0$, equal values on ϕ_{max} may be joined; this gives the oblique lines on the diagram with ϕ_{max} values marked at the bottom.

In most cases Frigistors will be operated around the maximum coefficient of performance. In some cases, for example, when the temperature difference is very small, or when heat dissipation from the hot junctions is improved by heavy finning or water cooling, or the heat load is small and it is desired to attain a large temperature drop, currents in the range I_ϕ to I_Q will be used. It must, however, be kept in mind that large departures from the maximum coefficient of performance are undesirable not only because more power is consumed for a given heat load, but also because it may not be possible to dissipate this extra power at the hot junctions, with the consequent rise of hot and cold junction temperatures.

When the hot and cold junction temperatures and the heat load are specified, and the question is how many couples are required and at what current they should be run, the procedure is as follows:

Follow the T_c horizontal until it intersects the ϕ_{max} line starting at T_h. Read the current I_ϕ at this point, the amount of heat extracted Q_c (if necessary interpolate along the I_ϕ vertical), and the value of the coefficient of performance ϕ (if necessary interpolate between the two oblique lines, but take account of the nonlinearity of the scale). Select a Frigistor which

*Needco Group of Companies.

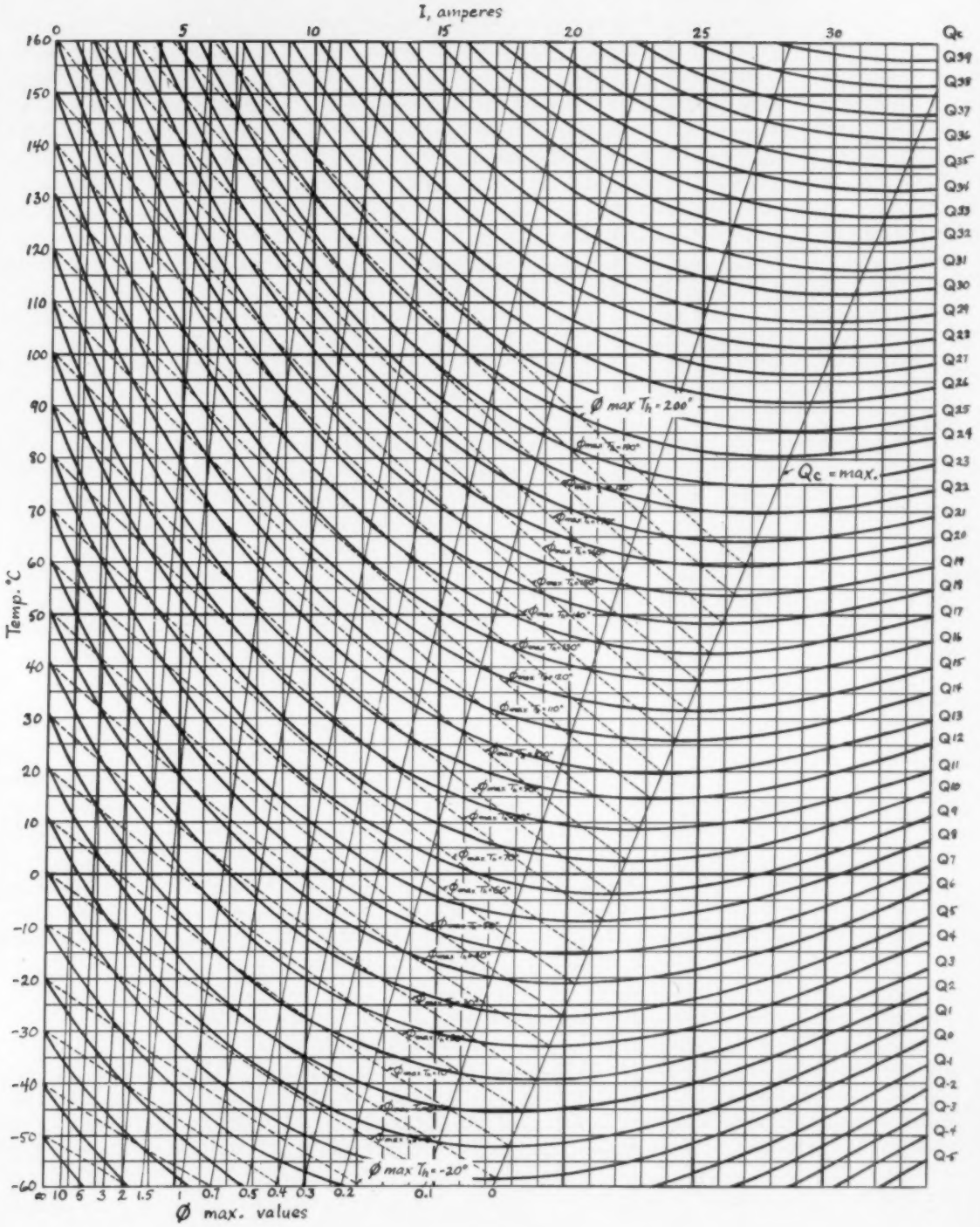


Fig. 1. Frigistor diagram.

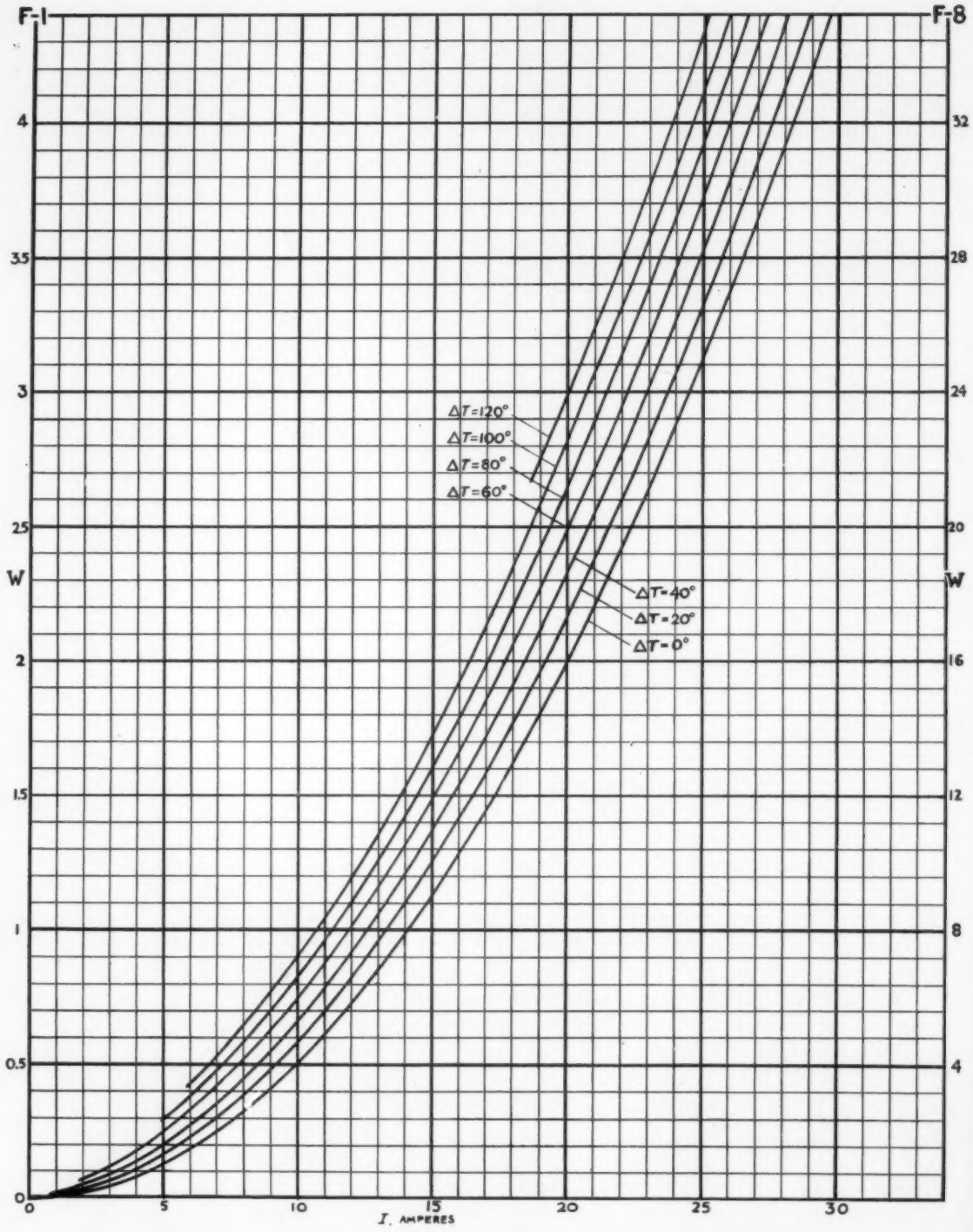


Fig. 2. Frigistor power consumption curves.

satisfies the heat load requirements. If the heat pumping rate of this Frigistor is slightly too low, find by how much the current has to be increased to satisfy the requirements. Calculate the power consumption from $W = Q_c/\phi$, the voltage from $V = W/I$, and the required rate of heat dissipation from the hot junctions from $Q_h = W + Q_c = Q_c(\phi + 1)/\phi$.

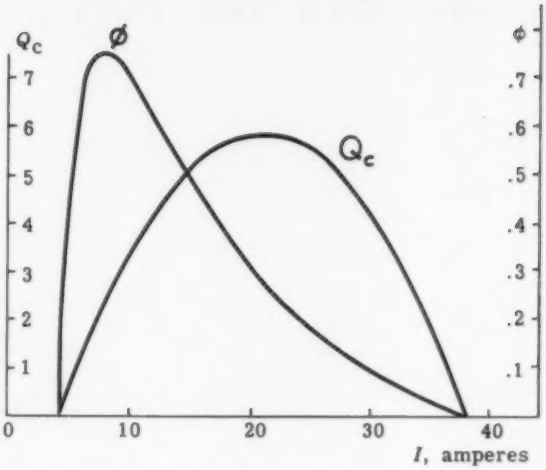
Example: Heat is to be removed from a refrigerated box at a rate of $10W$; $T_c = -5°C$ and $T_h = 40°C$.

The $-5°$ horizontal cuts the ϕ_{max} ($T_h = 40°$) line at $I = 11A$, $Q_c = 2.4W$ for an F-8 Frigistor. To remove $2.5W$ the current will have to be raised to 11.2A. Hence four F-8 Frigistors will be used at 11.2A. The coefficient of performance is approximately 0.4, hence the power required is $25W$ and the voltage $2.25V$ (series connection).

When the Frigistors are to work at a current much above that required for the maximum coefficient of performance the chart makes it possible to plot the coefficient of performance curve and the heat load curve for given T_h and T_c in a matter of minutes.

Example: A water-cooled Frigistor F-8 is to cool a baffle in a vacuum pump. Hot junction temperature is estimated 20°C and the required cold junction temperature is $-10°C$. What are the heat loads with which the unit can cope and what is the coefficient of performance at various currents?

The $-10°C$ horizontal cuts the Q_2 curve (giving $Q_c = 0$ for $T_h = 20°C$) at 4A; the Q_3 curve ($Q_c = 1W$) at 5.5A; the $2W$ curve at 7.2A; the $3W$ curve at 9.2A; the $4W$ curve at 11.6A; the $5W$ curve at 14.4A; and the Q_{cmax} line at $Q_c = 5.8W$, $I = 21.3A$. Hence curve Q_c on the sketch below. ϕ_{max} is 0 at $Q_c = 0$,



i.e. at 4A and goes up to a maximum where the $-10°C$ horizontal cuts the dashed ϕ_{max} ($T_h = 20°$) line, i.e. at 7.5A and ϕ_{max} is seen to be there around 0.75. From the power curves (Figure 2) we find that at 14.4A ($Q_c = 5W$) the power consumption for $\Delta T = 30°$ is $9.5W$, hence $\phi = 0.53$ and at 21.3A ($Q_c = Q_{cmax} = 5.8W$), the power consumption for $\Delta T = 30°$ is $20.7W$, i.e. $\phi = 0.28$. The points allow us to sketch the behaviour of ϕ_{max} (curve ϕ on the sketch). These are typical shapes for the $Q_c - I$ and $\phi - I$ curves at $\Delta T = \text{const}$.

The Frigistor diagram and power consumption curves can also be used for non-standard branch dimensions. In this case the current, the Q_c values, and the power consumption have to be multiplied by $2.5\ S/l$.

END

Proposed thermoelectric symbol

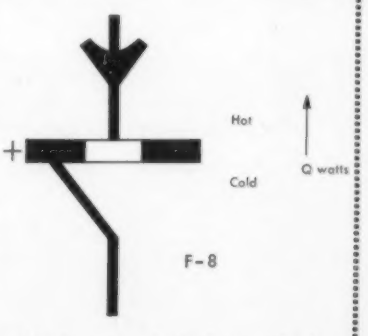
The thermoelectric industry has now reached the point where a special symbol to show a Peltier cooling device is necessary. Scientists at Needco Cooling Semiconductors Ltd. have developed this symbol for use on diagrams which show power supplies and temperature control circuits added to a normal electronic circuit diagram. It is like a transistor symbol because the latter is well known and has a workable set of conventions.

The body of the device has alternate black and white bars to designate P and N blocks used in the device. The electrons flow into a P block and leave by an N block. Thus, the positive lead goes to an N block and a small plus sign shows the polarity of leads.

By convention, the heat is made to flow in a direction opposite to the electron flow in the symbol. Consequently, the lower face is cold and the upper face is hot. It is easy to remember the direction of heat flow since the fall in energy level for both the electrons and the thermal energy is down the page. Heat is pumped up to the higher temperature level exactly as if it were an electrical current.

The illustration contains F-8 since it represents a Frigistor with eight couples.

It is not intended that this symbol be suitable for analysis, but merely to indicate functional operation of the device.



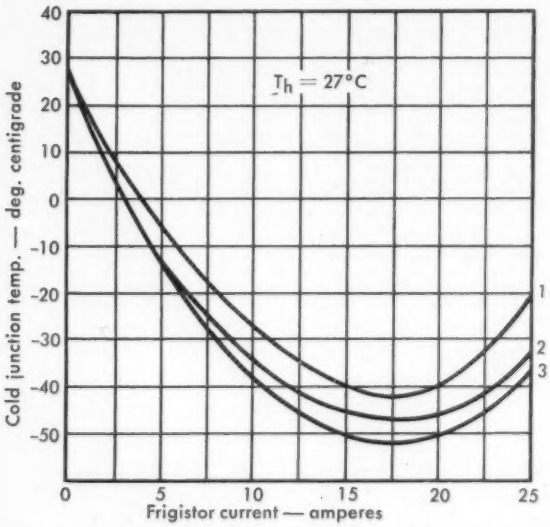
Readers are invited to submit suggestions for improving this symbol as a usable engineering device. Comments may be sent to the Editor of CEE, or Mr. J. Keane, Applications Dept., Needco Cooling Semiconductors Ltd., 5701 Cote St. Paul Rd., Montreal 20, P.Q.

The development of thermoelectric materials for refrigeration

C. A. A. MACPHEE*

Five months after the Needco laboratory buildings were completed, material suitable for thermoelectric cooling application was produced which equalled the currently accepted standards of the industry. Unsupported Frigistors made from these materials produce a value of $\Delta T = 68C$ at a hot junction temperature of 300K, when measured in vacuum (Curve 1).

To achieve this result, it was necessary to build up a staff possessing the requisite abilities and experience to devise techniques of measurement and to design the test equipment, laboratory apparatus and production machinery and, simultaneously, to conduct the research and development work necessary to produce material of this quality.



Curve 1 shows performance of couples prepared from zone-melted materials. Curve 2 shows average and Curve 3 optimum performance of couples prepared from zone-melted N-type and sintered P-type materials.

Progress on materials and methods was slow in the early stages, as very little of the instrumentation and equipment was available commercially. In consequence, the design and manufacture of instruments and apparatus absorbed a very large proportion of the effort available. As this equipment became available, the development of the materials was accelerated. Materials based on the pseudobinary systems Bi_2Te_3 — Bi_2Se_3 and Bi_2Te_3 — Sb_2Te_3 were developed, together with combinations of the two systems and, after intensive work on the development of both materials and production methods, the objective of $\Delta T = 68C$ was achieved.

Two other lines of work were also pursued, both based on the fact that oriented polycrystalline materials produced by modifications of the various standard crystallographic techniques possess undesirable mechanical properties. These materials have well-defined cleavage planes and, consequently, blocks can be split fairly easily along the corresponding crystal axes. Thus, the production of rugged devices necessitated either the development of an adequate supporting structure for the basic couple assembly or the introduction of mechanically strong materials. Other workers in this field have solved the problem in part by using large sizes for the two legs of the couple, thus avoiding a considerable part of the mechanical processing of a device. However, since if the ratio of length to area of a couple is maintained constant the performance of the device is also constant, there are obvious advantages to be gained by using the smaller sizes. Consequently, the decision was taken to reduce the size of the device and to sacrifice a part of its performance to obtain robustness by using a supporting structure. The structure was designed to give the highest possible packing density of thermoelectric materials, so reducting the losses inherent in this form of construction. The resulting nominal loss in ΔT max was 14.5%, but since few devices are ever operated at ΔT max this loss was considered tolerable and the reception accorded these devices demonstrated the correctness of this decision. Of course, where the relative fragility of an unsupported structure is unimportant, by virtue of the overall design of the apparatus into which the frigistor is incorporated, the maximum performance obtainable with these materials may be utilized.

Powder metallurgy provides new opportunities

Simultaneously, the development of materials produced by the methods of powder metallurgy was undertaken and it was obvious from the beginning that a material having much superior mechanical properties could be produced if the same thermoelectric properties could be obtained. At the present time, the P— type material produced in this way is extremely satisfactory. In fact, devices using this type of P— material and an oriented polycrystalline N— material are in production with ΔT max 70C at Th = 300K, when measured in vacuum (Curve 2). By a selection process, values of ΔT max 75C can be obtained and the highest value recorded so far is ΔT max = 78C, under the same conditions (Curve 3). It is believed that these values are the highest obtained for production devices in the industry.

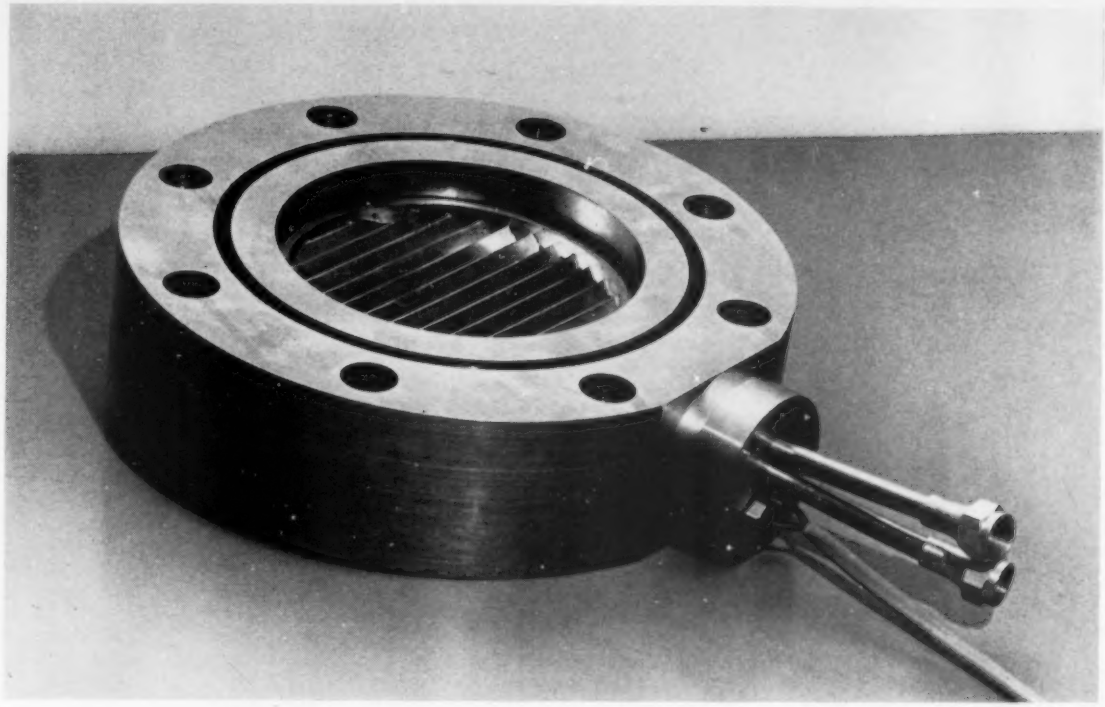
The N— material produced by these methods is not yet as good as that produced by crystallographic techniques, but values of ΔT max 60C at Th = 300K when measured in vacuum can be obtained. Intensive study is being devoted to this material to effect the desired improvement.

Thus, although the performance of couples made from material produced by powder metallurgical methods is not quite as good as that of couples made from material produced by crystallographic techniques, where mechanical stability is all-important they are the only devices which can be used. Also, the use of an hybrid couple together with a supporting structure as discussed above results in the production of a rugged device with very little sacrifice in performance as a heat pump.

Development has not been limited to the fields out-

(Continued on page 54)

*Vice-president, research and development, Needco Group of Companies, Montreal.



Thermoelectric cooling improves baffles for vacuum pumps and systems

ROMAN POST POSLAWSKI, MEM. AIME & AMERICAN VACUUM SOC.*

A thermoelectric baffle has been developed for use as a refrigerating element in vacuum pumping systems, which can operate down to temperatures that are adequate for the condensation of commonly used diffusion pump fluids. Its operating costs are compared with those for a conventional baffle.

The Committee on Standards of the American Vacuum Society defines a Baffle as a system of cooled walls, plates or tubing placed near the inlet of a vapor pump to condense back-streaming vapor at a temperature below that of the room and return the fluid to the boiler. The baffle plates may be located in the head of the pump or in a separate housing attached to the inlet.

A refrigerated trap is defined as a system of cooled walls, plates or tubing placed beyond the baffle or the condenser to reduce the partial pressure of vapor migrating from the pump or from the vacuum system, and from which the condensed vapor cannot return to the pump boiler.

It is intended that the Needco equipment described in this article be known as a baffle, rather than a trap because the contemplated chevron temperatures will not permit cryogenic trapping of air, CO, CO_2, H_2, O_2 or N_2 in measurable quantities. The primary function of this baffle is to recover "back-streaming" pump vapor such that the working vacuum will remain free of pump fluid contamination.

A diffusion pump, having reached a base pressure in the system, produces an equilibrium condition in which the number of particles flowing into the mouth of the diffusion pump is equal to the number of particles flowing out and back toward the vacuum space. It is at this time that the use of a cold baffle becomes necessary, not to further lower the pressure in the system, but to prevent system contamination.

The Needco baffle is designed to operate through a wide range of chevron temperatures down to the order of —25 to —35 C. That temperature is adequate for the condensation of commonly-used diffusion pump fluids as shown in Fig. 2.

Thermoelectric elements provide cooling

The refrigeration effect of this baffle is accomplished by means of a Frigistor thermoelectric assembly consisting of several Neelium couples. Neelium is a quaternary thermoelectric alloy of bismuth, tellurium, antimony and selenium.

*President, Needco Cooling Semiconductors Limited, Montreal.

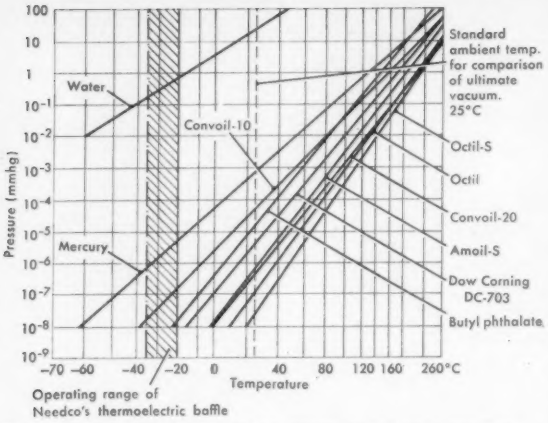


Fig. 2. Pumping fluid vapor pressure vs temperature.

Upon reversal of the current the Frigistor will act as a heat pump and raise the temperature of the baffle from —35 C to room temperature within 45 to 60 seconds, allowing defrosting of the cooling member.

The Needco baffle is not a new concept, but is an improved version of existing baffles. Many present-day vacuum systems use baffles rather than refrigerated traps (cryogenic pumps) even though the former have limitations. The Needco baffle is subject to the same limitations in its application, but its over-all ease and economy of operation provides a system of much greater flexibility.

The Needco baffle is a self-contained, solid state, refrigeration device which does not require refrigeration-compressor equipment. The important saving to the user appears in the form of space not taken up with auxiliary equipment. In addition, the normal problems of maintenance of a compressor type unit are eliminated.

The conventional type of refrigeration equipment requires pressure-refrigerant lines, heavy duty power lines and, if the unit is large, cooling water for the compressor. The Needco baffle requires only a power drop cord which supplies power to the Frigistor through a power supply control furnished with the baffle.

Cooling water is required for the Needco baffle. However, since cooling water must be supplied to the diffusion pump, the baffle may be connected in series with it. The only additional piping required may be a flexible hose from the outlet of the baffle to the inlet of the diffusion pump.

In an area having several units, compressor noise could become objectionable and transmitted vibration may actually be dangerous. Neither of these factors is present in a thermoelectric baffle because it has no rotating or reciprocating parts.

The Frigistor is assembled in the baffle's internal sleeve ring at the factory as a permanent installation. No damage can be done to the unit unless, through accident or intent, some part is broken or distorted such that it no longer meets factory specifications. Power must not be applied to the Frigistor except when cool water is flowing through the unit.

The power supply furnished with the baffle is also a solid state device and possesses electrical and mechanical stability. With the exception of occasionally checking the water connections, the maintenance required for this equipment is negligible.

Operating costs and power consumption

The cost of water for mechanical refrigeration baffles depends upon whether the size and location of the unit dictates the use of water cooling. It will require the same amount of water for the diffusion pump as will installations using thermoelectric baffles. In the latter case there is no additional cost for the water used by the baffle. In an area requiring treatment of the water before usage, a water cooled mechanical refrigeration system will have appreciably higher operating cost for the water used.

Comparison of compressor-operated Freon baffle and Frigistor-operated baffle (24 hrs per day for 365 days)

	Annual power consumption
⅛ hp compressor at 150 watts	1,314 kwh
F-8 Frigistor at 10 watts	87.6 kwh
Saving	1,226 kwh
1/3 hp compressor at 410 watts	3,591.6 kwh
F-8 Frigistor at 40 watts	350.4 kwh
Saving	3,241.2 kwh

The development of a baffle was complex and was based on the following general philosophy:

(a) The necessity of obtaining proper drop in temperature on the baffle chevron;

(b) The necessity of avoiding any contamination of

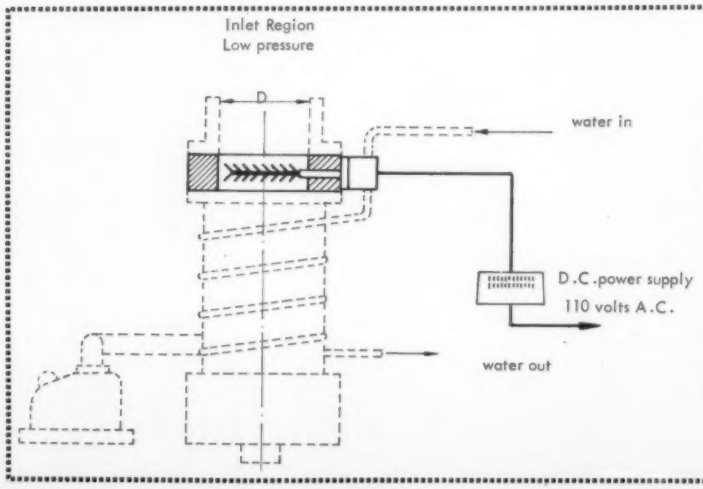


Fig. 3. Connection of thermoelectric baffle in vacuum system.

New standard adopted by National Research Corp. and Consolidated Vacuum Corp. to increase efficiency with larger bore molecular pump fitted in same ASA standard.

Class	**Dimension D — inches**				
ASA Std.	4	6	10	16	20
New Std.	5¼	7	11		
Special		9	12	32	36

the high vacuum system by exposed resin.

Several resins showed a high degassing ration which made it impossible to obtain proper vacuum of 10^{-5} to 10^{-7} or 10^{-8}. It was extremely difficult to solve these two aspects at the same time. It is obvious from literature and descriptions of experiments done in the U. K. and in the U.S.S.R. that other workers have not been able to solve this problem.

There appeared to be two or three approaches which would offer a solution:

(a) Direct water cooling of the Frigistor. This is feasible, but it would be necessary to insulate the hot junctions from the water to avoid any possibility of galvanic corrosion.

(b) Improvement of the heat exchange surfaces between the water and the heat sink by using a more efficient heat exchanger, e.g. one made up from pin-plate, or by tapping the holes in the existing heat exchanger with a coarse thread to increase the area of the copper-water interface.

(c) Improvement of the heat exchange surfaces between the Frigistor and the heat sink.

A methodic evaluation was carried out in the Needco laboratory and it was determined that the contact between a Frigistor and cold member deteriorated during cycling. To overcome this effect, epoxy was replaced by a new method of attachment which did not deteriorate during prolonged cycling tests.

Several baffles are under evaluation at U. S. corporations. Information released by RCA Lancaster Laboratories in Pennsylvania shows that backstreaming is infinitesimal and cannot be detected by practical measurement.

Needco Group of Companies is co-operating with a number of high vacuum system manufacturers to introduce the thermoelectric baffle as a standard component in their equipment.

I would like to acknowledge the help of the U. S. Government in allowing Needco to use its facilities for long-term testing of thermoelectric baffles.

This baffle is an example of successful application of thermoelectricity in industry. It is reliable and its price is competitive with conventional baffle systems. END

Semiconductor—continued

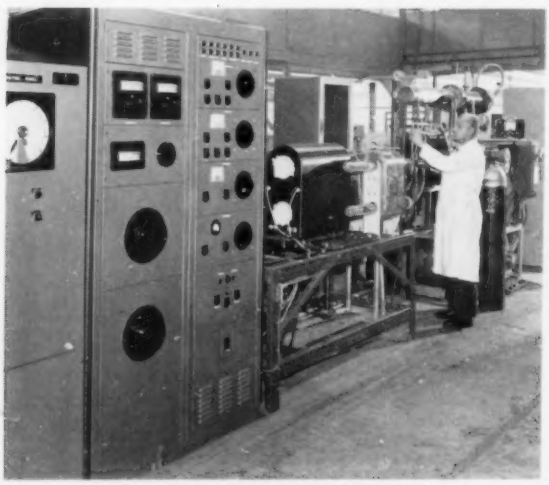
The general conclusion is that, in the present stages, thermoelectric applications are suitable for the three previously mentioned applications: military, instrumentation, industrial—and are now going into the fourth, the field of appliances.

The work of Professor A. Ioffe and Dr. J. R. Drabble contributed largely to the foregoing achievements. In particular they contributed to the better understanding of the theoretical problems of energy transport in semiconductor alloys for cooling and power generation purposes. Present Western World work is now moving from the theoretical stage into the stage of practical application.

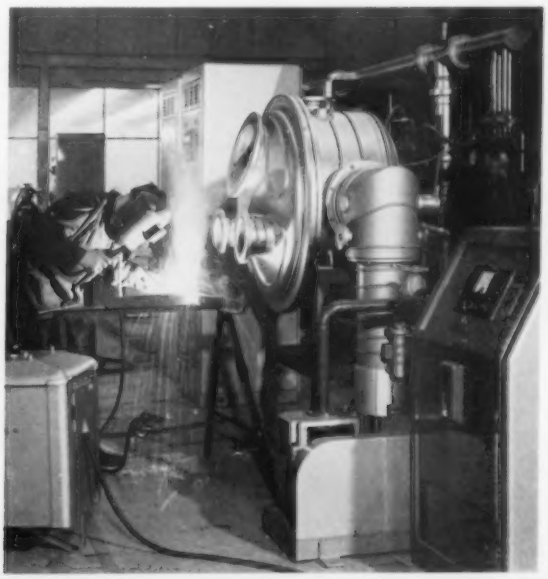
At the Joint Technical Society Department of Defense Symposium on Thermoelectric Energy Conversion, Dallas, Texas, it was stated by P. S. Forsyth, who was at the Leningrad Laboratory, that the Russians are concentrating their efforts on cooling, not on power generation. This is not the opinion of the writer, who is aware that the Russian information in this field is rather misleading, and that their work is concentrated on military applications of thermoelectric power generation. Furthermore, their free releases in this work seem to have ceased from the time when the Western World showed an interest in the thermoelectric field and produced fine results.

Future looks promising for thermoelectricity

The work of the Western theoretical physicists, e.g. Dr. Drabble and other workers, inspires us with confidence that the best theoretical fundamentals for future work are already well on the way. Large government departments, as well as private corporations, are engaged in this field. Firstly, this can improve the available material for the theoretical workers and, secondly, it can stimulate the application of thermoelectricity in our industry, and also in our everyday lives. END



Section of Needco metallurgical department



Construction of master alloy furnaces

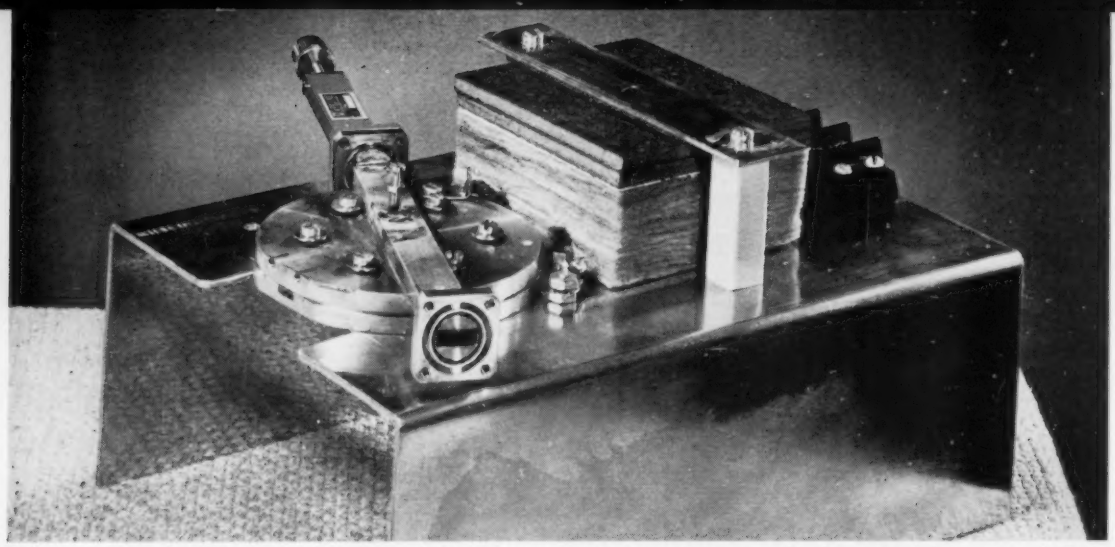


Fig. 1. Thermoelectric converter (right) with its output connected to microwave circuitry containing a tunnel diode.

Low impedance thermoelectric device powers tunnel diodes

E. L. R. WEBB, SEN.MEM.IRE and J. K. PULFER, MEM.IRE*

Tunnel diodes, being very low impedance devices, require low impedance power sources. Conventional supplies are bulky and inefficient. Introduction of new thermoelectric materials made it feasible to build supplies with desirable characteristics.

Both tunnel diodes, and thermoelectric supplies are new semiconductor devices which have recently become available to the circuit designer. Both are inherently low impedance devices, and it has been found that the one can provide an ideal power supply for the other.

Fig. 2 is a portion of the voltage-current curve of a typical commercial germanium tunnel diode showing the familiar negative resistance characteristic. To obtain a stable dc operating point in the negative resistance region, the slope of the load line must be steeper than that of the diode characteristic, as shown. In other words, the internal resistance of the power supply must be lower than the negative resistance of the diode.

The slope of the ac load line is determined by the application. For amplification, it should be just slightly steeper than the diode curve at the desired amplification frequency, and much steeper at all other frequencies.

For oscillation, the slope must be low at the desired operating frequency. Whether the oscillation is sinusoidal or some form of relaxation oscillation depends on the nature of the impedance represented by the load line.[1]

In any case, whatever the application, it is important that the power supply impedance be as low as possible so that it is not a significant factor in the behaviour of the circuit. Since tunnel diodes with a negative resistance less than 1 ohm are possible, a useful power supply should have an internal resistance of the order of tens of milliohms.

To obtain by conventional means a really low resistance dc source from which to operate one or more tunnel diodes, one must be prepared to put up with considerable weight and inefficiency. For example, a resistive voltage divider connected across a two-volt lead-acid storage cell would have to draw 10 amperes in order to maintain 200 millivolts across a 20 milliohm resistor acting as the source resistance for the diode. This amounts to 20 watts drain from the battery and for extended operation would entail a substantial "trickle-charger".

If one tried to save weight by dispensing with the storage cell and substituting in its place a conventional filter, a serious ripple problem would arise because of the difficulty of obtaining suitable filter components for this low impedance level. The situation also tends to become ridiculous, as regards efficiency, for any tolerable degree of ripple.

With the advent of commercially available thermo-

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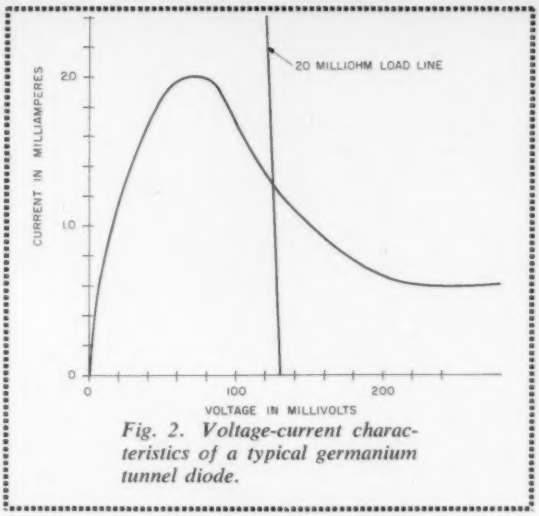

Fig. 2. Voltage-current characteristics of a typical germanium tunnel diode.

electric material, having a figure of merit of 2 or 3×10^{-3} deg. C^{-1} and capable of operation up to temperatures of at least 200 C, it becomes quite feasible to construct an ac to dc converter which is very competitive with the voltage divider/storage cell combination cited above. Such thermoelectric converters need weigh only a pound or two and need consume no more power than the resistive divider alone. The input power can be supplied from any ac or dc source at any convenient impedance level. For ac operation the output is substantially pure dc, and it is easy to provide good electrical isolation of the output circuit and still maintain excellent control by adjusting the input power electrically.

At least one such device has been mentioned in the literature.[2] It makes use of a single lead telluride couple operating at temperatures so high as to require encapsulation by techniques not normally found outside the vacuum tube industry. We have chosen to use, instead, several bismuth telluride couples in series operating at relatively low temperatures to provide the desired output without the need for special techniques.

Design of power supply

To try out the idea, and while waiting for procurement of commercial thermoelectric modules, we fabricated a number of couples, each equipped with an individual resistance heater. The heaters were of Nichrome ribbon wound on small mica cards and held by sheet nickel clips soft-soldered to the hot junction straps of the couples. Five couples were connected in series, as shown in Fig. 3, by means of sheet copper rectangles that also served as cold junction heat sinks. The whole converter was mounted breadboard fashion on a piece of perforated transite ceiling tile. The pairs of ceramic stand-off insulators flanking each thermocouple subassembly served as tie points for the heater leads. The heaters were also wired in series, along with an ammeter, and connected to the secondary winding of a small filament transformer. The tin-lead solder holding the heaters in place limited the hot junction temperature to less than 183 C, which is near the upper limit of useful output for the semi-conductor materials used. However, the output was still adequate to make a typical Esaki diode oscillate steadily at about 300 Mc when connected directly to the converter. The internal inductance of the converter deduced from the diode parameters and the observed frequency of oscillation was about 40 nh, or roughly the equivalent of two inches of ordinary hook-up wire.

Apart from this relatively high inductance, the breadboard model had two other defects which would have been corrected had we continued to use it. Firstly, the electrical resistance of the pressure contacts between the metallic end straps of the thermocouples and the copper cooling fins was erratic and tended to increase with time. This eventually ruined the internal resistance of the converter which was initially about 50 milliohms. The second defect was more of a nuisance and arose from the absence of thermal insulation on the exposed surfaces of the heaters. Even small drafts from an open window caused temperature fluctuations at the hot junctions that showed up as a new kind of very low frequency noise. Both these defects were eliminated in the second model by the use of a compact all-soldered module suitably lagged by Fiberglas insulation.

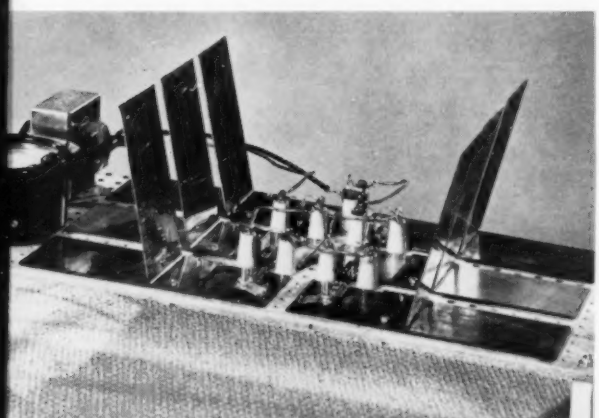

Fig. 3. Breadboard model thermoelectric converter used to prove feasibility as power supply for tunnel diode.

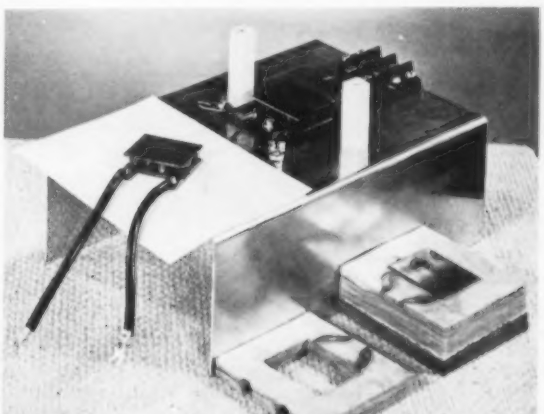

Fig. 4. Second model of thermoelectric converter partially disassembled to show simplicity of construction.

The main purpose of the breadboard model was to demonstrate feasibility and show that hum or ripple from the ac heater was not detectable either directly or by inference from the spectrum of the oscillating tunnel diode, which is very sensitive to variations in supply voltage.

The second model is shown partly disassembled in Fig. 4. The spare module resting on the white card gives a better view of the arrangement of the cylindrical semi-conductor posts and the metallic end straps. The thermoelectric modules shown in Fig. 4 were obtained from Materials Electronics Corporation of Trenton, N.J. The electrical insulation between the aluminum heat sink or chassis and the module is a thin (.001 in.) sheet of mica. A dab of silicone grease improves the heat transfer but also makes things slippery. It was, therefore, desirable to constrain the module by a shallow insulating collar that also serves to fasten and protect the mica. Hard anodizing of the aluminum to give a thin insulating surface would be a better way to provide electrical insulation and at the same time good thermal contact.

At the time of construction we had only facilities for treating small pieces of aluminum, such as the wafer installed on the hot (top) side of the module. This wafer serves both as electrical insulation from the heater and also as a thermal equalizer to keep the six hot-junction straps at a more uniform temperature. The heater itself is a length of Nichrome ribbon wound on a mica card and with the ends extended to the terminal block. In operation the module is surrounded by the Fiberglas collar shown in the foreground. The thermal insulation is completed by the Fiberglas top cap which also serves as firm but gentle compression spring to keep the whole assembly in place. The thin rectangular copper block resting on the top cap also has a dual purpose. It is both a mechanical pressure plate and a thermal capacitor which increases the thermal time constant of the converter. The assembly is completed by some fibreboard shims and a damping box, as shown in Fig. 1. The electrical output from the thermocouples is carried by heavy flexible leads, one of which is usually grounded to the chassis, depending on the polarity desired.

Performance of power supply

The output resistance R of the converter, as measured at 60 cps was 0.014 ohms cold and about 0.020 ohms under typical operating conditions. However, the description of the dynamic behaviour of the converter requires an equivalent circuit such as that in Fig. 5(a), as has been shown in a separate paper.[3] The additional resistance R_π, which may be about the same size as R, is hidden from the output at all frequencies above a few cycles per second by the enormous size ($\sim 10^4$ farads) of the shunt capacitance C. The values of R_π and C may be measured by a transient method described below. The circuit time constant of about 2 minutes makes it plain why the output is so well filtered, even though the input may have 100% ripple at 60 cps. The efficiency of the converter must be defined as the power delivered to the load, divided by the heat input Q. It has been shown[3] that this ratio may be reduced, with certain reservations about the size of R_L, to

$$\eta = \frac{\Delta T}{T} \cdot \frac{R_\pi R_L}{(R_\pi + R + R_L)^2}$$

where $\Delta T/T$ is the Carnot efficiency of an ideal heat engine, which in one case may be about 30%. Although it is not strictly correct, we can estimate the maximum efficiency by putting $R_L = R_\pi + R$, in which case we get

$$\eta = \frac{\Delta T}{4T} \cdot \frac{R_\pi}{R_\pi + R}$$

If R_π is assumed to be about $R/2$, then one might expect an efficiency of about

$$\eta = \frac{0.3}{4} \times \frac{1}{3} \text{ or } 2.5\%$$

Fig. 6 shows the variation of the open circuit voltage at the converter output upon removal of a short circuit that had been applied to the output terminals for several minutes. Referring to the equivalent circuit, we see that the voltage should rise immediately to $V' = V.R.(R + R_\pi)^{-1}$ and then slowly to V. Having measured V', V and R we can compute R_π from the above formula. Fig. 6 also gives the time constant $t_{oc} = R_\pi C$, hence C may also be computed.

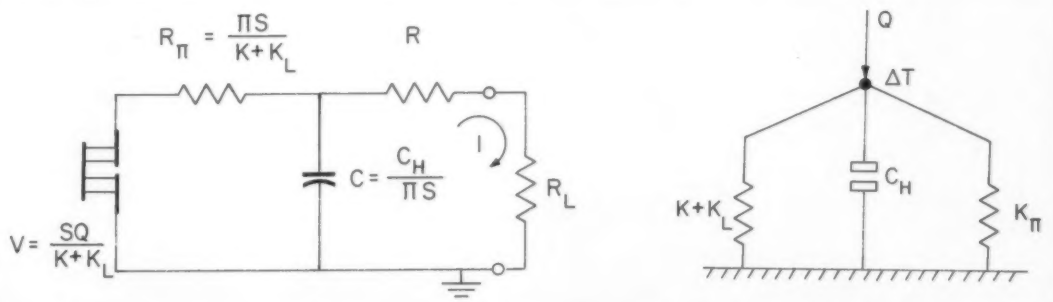

Fig. 5a (left). Electrical equivalent for the converter operating under constant heat input. π and S are Peltier and Seeback coefficients. Fig. 5b (right). Thermal equivalent showing ordinary heat conductances K and K_L, internal and external respectively to the thermo-electric materials. Conductance K_π represents heat pumped by Peltier effect of load current I. Thermal capacitance C_H is storage of heat at hot junctions.

The following values were determined experimentally:

$$t_{oc} = 114 \text{ sec.}$$

$$R\pi = R\left(\frac{V}{V'} - 1\right) = 0.013 \text{ ohms}$$

$$C = \frac{t_{oc}}{R\pi} = 8240 \text{ farads}$$

It is difficult to draw an equivalent circuit for the power supply which would represent it adequately at high *RF* frequencies. Both the internal inductance and shunt capacity are distributed and cannot be replaced by lumped components.

A series inductance of 60 nh, and a shunt capacity of 200 pf connected to the output terminals of the circuit in Fig. 5(a), are a good approximation below 50 Mc.

Performance of tunnel diode devices

A tunnel diode microwave oscillator driven by the thermoelectric source, operated smoothly and continuously over the negative resistance portion of its characteristic. With the cavity shown in Fig. 2 about 2 microwatts of power could be obtained at 6500 Mc with a commercially available diode manufactured by the Sony Company of Japan. The diode (shown in the lower right-hand corner of Fig. 7) has a negative resistance of 50 ohms, a capacity of 2.2 pf, and a package inductance less than 1 nh.

Input to the diode was 125 mv at about 1.2 ma or 150 microwatts, so that efficiency was about 1.3%.

To determine the maximum usable frequency which could be generated with this tunnel diode, a K-band waveguide was coupled to the cavity (see Fig. 1) and harmonics of the oscillator coupled out. The highest frequency obtained, 21,500 Mc, was believed to be the fourth harmonic of the oscillator operating at approximately 5400 Mc. The available output power was approximately −50 dbm or 0.01 microwatt.

The oscillator was voltage tunable over a range of about 200 Mc at 6000 Mc, or about 3%.

A second application of the thermoelectric supply was to power the high current tunnel diode pulse generator shown in Fig. 8.

The diode used was a type TED 105, manufactured by Standard Telephones & Cables. The oscillator produced pulses 1 usec long at a rate controlled by the inductance L_s. The pulses were about 125 millivolts in height at the output, with the current through the diode being about 250 milliamperes. The output impedance of the generator was, therefore, about 0.5 ohms. Rise time of the pulses was measured on a sampling oscilloscope to be 15 to 20 nanoseconds. The fast risetime attained with this simple circuit was achieved by having a very low power supply impedance, so that the charging and discharging time constants were kept to a minimum.

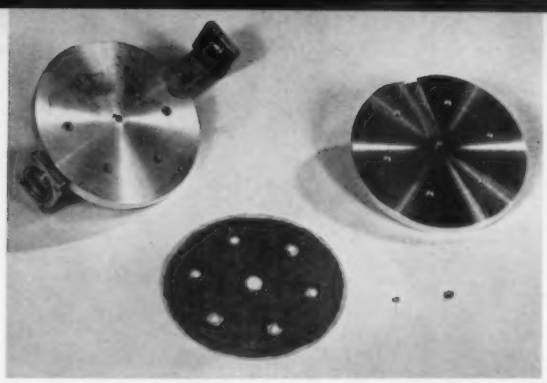

Fig. 7. Tunnel diode cavity showing silvered mica bypass capacitor. Dots at right are tunnel diode and spring.

Conclusions

Thermoelectric power sources are almost ideally suited to operating tunnel diode circuitry. The properties of the thermoelectric supply, which are particularly important, are:

(1) very low output resistance at reasonable efficiency

(2) negligible ripple when operated from an ac source

(3) ability to vary output potential smoothly and continuously over the entire range

(4) ability to operate from a source of ac or dc power at almost any impedance level. END

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2. *C. J. Hubbard, "Thermoelectricity and Esaki diodes," Proc. IRE, Vol. 48, No. 7, July, 1960, (advertisement, page 4A).*
3. *E. L. R. Webb, "Equivalent circuits for a thermoelectric converter." This paper has not been published yet; readers wishing to be advised at time of publication, may write to the Editor of CEE.*

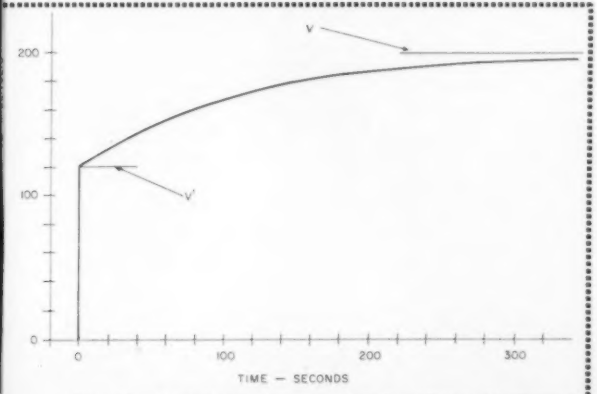


Fig. 6. Variation of open circuit voltage of thermoelectric power supply after removal of short circuit.

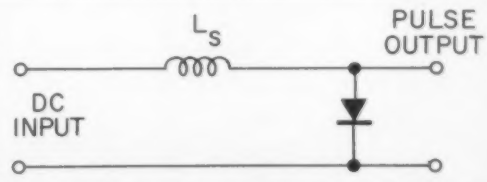


Fig. 8. Circuit of high current tunnel diode pulse generator. Pulse rate is determined by size of Ls.

Fig. 1. Inside view, looking aft, shows the well and a light mounting station suspended from the overhead crane.

New floating laboratory facilitates underwater acoustic measurements

G. W. McMAHON, MSC*

The Defence Research Board's Naval Research Establishment at Dartmouth, N.S. has a new floating laboratory in which underwater acoustic experiments and measurements are made. This article describes the laboratory and typical experiments on transducers, sound sources, and domes.

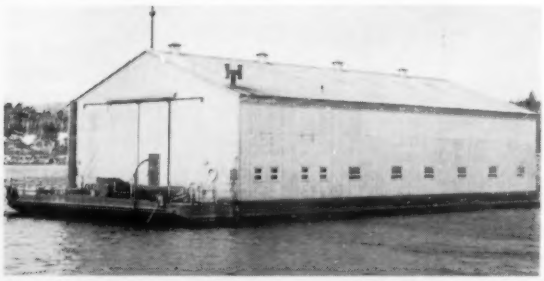


Fig. 2. NRE's acoustic barge moored in Bedford Basin.

Advances in sonar, the detection of submerged submarines by underwater sound, require that experiments be carried out both at sea and under more controlled conditions in the laboratory. Experiments in the laboratory should, however, take place under conditions which are close to the desired open ocean environment. Anechoic tanks have many limitations and a floating laboratory is necessary if research is not to be limited by facilities.

Almost since its formation in 1947, the Defence Research Board's Naval Research Establishment at Dartmouth, N.S., has made wide use of a small floating laboratory. In addition to the calibration of transducers for sea trials, new designs of transducers for the conversion of electrical energy to acoustic energy and vice versa are evaluated, novel forms of sound generators such as electric sparks and explosives are examined, transmission characteristics of metals and plastics are determined, sonar domes are tested and the effect of baffles and baffle materials measured.

*DRB Naval Research Establishment, Dartmouth, N.S.

It became apparent in 1955 that the limit of the then existing acoustics barge was fast approaching and planning began on a new laboratory which would meet requirements for the foreseeable future. Following a careful examination of future needs, the conclusion was reached that a new laboratory was required which was specially designed for the work. The old floating laboratory had to be moored alongside a jetty and this increased the difficulty of obtaining accurate, reliable results, the measurements being affected by reflections from the jetty structure and the sea bottom. It was specified that the new barge should be capable of being anchored away from a jetty in water about 200 ft deep.

The Naval Research Establishment carried out the functional design specifying the characteristics of the laboratory required for the scientific work. The detailed design, plans and specifications were drawn up by the Royal Canadian Navy. Constructon of the barge, supervised by the RCN, was completed by the Halifax Shipyards Limited in August, 1959.

The new laboratory was fitted with scientific equipment and put in operation early in 1960. It is moored in a large sea water inlet, Bedford Basin, 1,800 ft off shore in 150 ft of water. The location, which is 3 miles from NRE, is quiet and well sheltered from the prevailing south and west winds.

DESCRIPTION OF THE LABORATORY

Mechanical equipment

The welded steel hull is 118 ft long by 56 ft wide and contains a large well, 60 ft x 30 ft, open to the sea. The main working area of the barge, including the well, is covered by an aluminum deckhouse, 97 ft long x 42 ft wide, flush with the port side of the hull (Figure 2). Specially enclosed areas such as laboratory, generator room, washroom, lunchroom and office are located within the deckhouse along the port side.

The well is spanned just above the water line by two moveable platforms which are supported by rails attached to each side of the well. The platforms are power driven and can be easily and accurately placed in position. On each platform is a travelling trolley which supports a light mounting station capable of handling equipment up to 300 lbs. The telescoping shaft of the light mounting stations can be adjusted to suspend equipment at any depth from 7 ft to 15 ft (Figure 1). The rotation of the shaft can be remotely controlled from the laboratory and is coupled through selsyn motors to the chart drive of a polar recorder.

A heavy mounting station, which can be attached to brackets at either end of the well, is capable of handling equipment up to 3 tons (Figure 3). This station has two concentric shafts so that two units, such as a sonar dome and a transducer can be mounted on separate shafts and rotated either together or independently. Rotation of the heavy station is remotely controlled and coupled to a polar recorder.

To attach equipment, the entire mounting station is lifted clear of the water by the overhead crane. This traveling crane enables loads of up to 5 tons to be placed anywhere within the deckhouse. The mechanical handling arrangements were designed to facilitate the setting up of experiments and to enable the adjustment of the geometry to be made easily and accurately.

In order to keep the noise level low, electrical power is supplied to the barge by submarine cable. However, to insure against shore power failure and the need to move the barge to a location without shore power, a 35-kva diesel generator is also installed.

Fig. 3. This heavy transducer station, shown being lowered into position at the forward end of the well by the overhead crane, can support loads up to three tons.

Electronic equipment

For most experiments special electonic equipment has to be assembled and, indeed, in some cases, it is the electronic equipment as part of a system which is under examination. The only permanent electronic installation is the equipment required to calibrate underwater electroacoustic transducers: either hydrophones, the underwater equivalents of microphones, or projectors.

The basic transmitting equipment consists of an oscillator, power amplifier and monitoring devices such as frequency meter, oscilloscope and VTVM. Sometimes it is required to carry out work under pulsed cw conditions; a pulse modulator is then inserted between the oscillator and the amplifier (Figure 5).

Figure 6 is a block diagram of the receiving equipment for pulsed transmissions. The calibration inject circuit inserts a voltage into the hydrophone receiving circuit so that, by comparison, the open circuit sensitivity of the hydrophone can be obtained. Figure 4 shows some of the permanent calibration equipment, including the polar recorder.

TYPICAL EXPERIMENTS

Acoustic calibration of transducers

The study of underwater acoustics is dependent upon the accurate determination of the electrical and acoustic characteristics of the transducers used to convert electrical energy to acoustic energy and vice versa. In order to obtain a complete evaluation of the performance of a transducer, three distinct measurements are required: the electrical impedance or admittance, the axial sensitivity and the variation of sensitivity with orientation. In general,

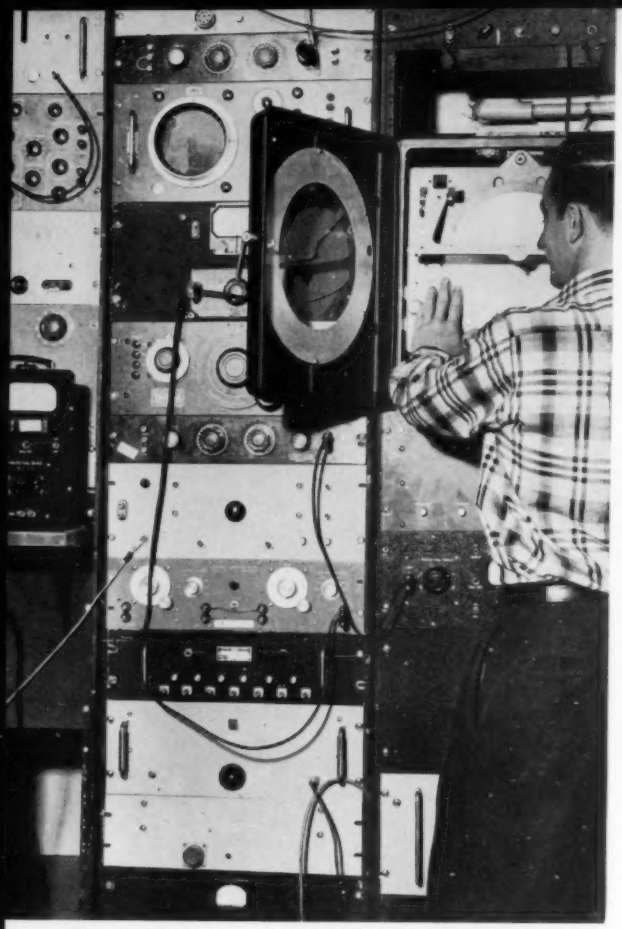


Fig. 4. Operator instals chart paper in polar recorder. Racks hold some of the electronic instrumentation used.

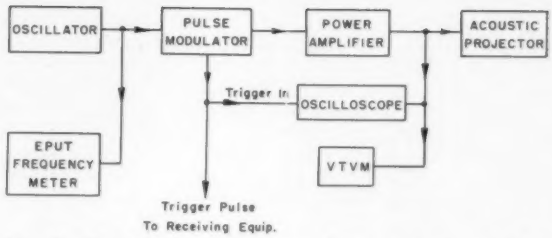


Fig. 5. Block diagram of transmitting equipment. Pulse modulator is added for tests under pulsed cw conditions.

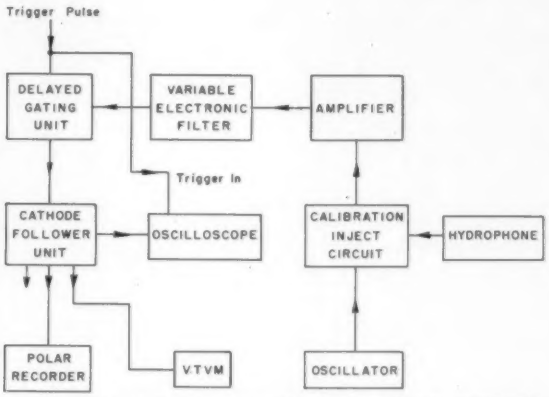


Fig. 6. Receiving equipment. Open circuit sensitivity of the hydrophone is obtained by a comparison method.

NRE underwater acoustic laboratory

all three factors are frequency-dependent and measurements must therefore be obtained over the required frequency range of operation. Equipment is available to calibrate transducers over a wide range, from low frequencies to over 100 kc.

The electrical characteristics of the transducers are obtained using standard admittance or impedance bridges over the frequency range of interest using a point-to-point technique. An automatic impedance or admittance plotter is however, being designed to speed up this procedure. Analysis of the electrical data enables the components of the electrical equivalent circuit to be calculated.

To determine the sensitivity of a transducer an absolute method, usually called the reciprocity technique, can be used. In this method two further transducers, knowledge of the sensitivities of which is not necessary, are required and at each frequency three measurements are taken. A calculation involving only the ratios of the observed currents and voltages, yields the sensitivity of any of the three transducers.

To avoid this rather laborious and time-consuming process, in the case of a hydrophone calibration, the usual procedure is to determine the sensitivity of the test hydrophone using a standard projector calibrated by the reciprocity technique to develop a known field. Secondary calibrations of projectors are carried out using standard hydrophones. Standard transducers for both hydrophone and projector calibrations are available up to frequencies over 100 kc.

The directional response is obtained with the test transducer mounted on a rotating station. The transducer is rotated through 360 deg and the sensitivity as a function of angle is recorded on a polar recorder. The calibration results obtained from a transducer resonant at about 38 kc are given in Figures 7, 8 and 9.

Acoustic calibrations are seldom routine: each calibration requires careful consideration of the experiment, particularly of the geometry and possible reflections from the surface and bottom. With directional transducers few problems occur since the proximity of the surface has little effect. However, care has to be taken to ensure that the test distance is sufficient for the measurements to be made in the Fraunhofer region of the transducer. With less directional transducers, special techniques have often to be used, such as a surface baffle to break up specular reflections from the surface, and pulse techniques.

Wide range of experiments being conducted

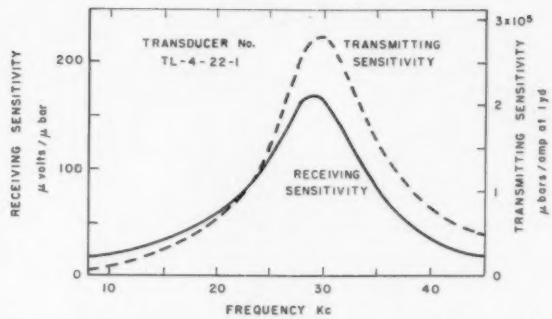


Fig. 7. Transmitting and receiving sensitivity curves for a transducer resonant at about 28 kilocycles/sec.

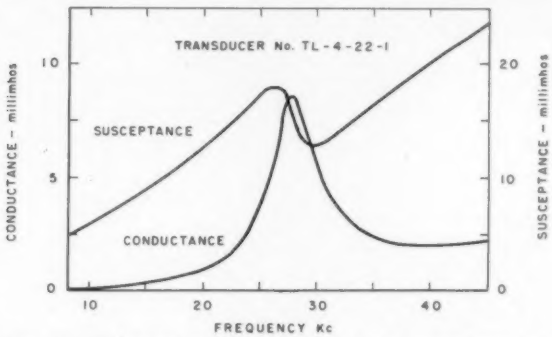


Fig. 9. Electrical characteristics of the transducer of fig. 7; equivalent circuit can be calculated from them.

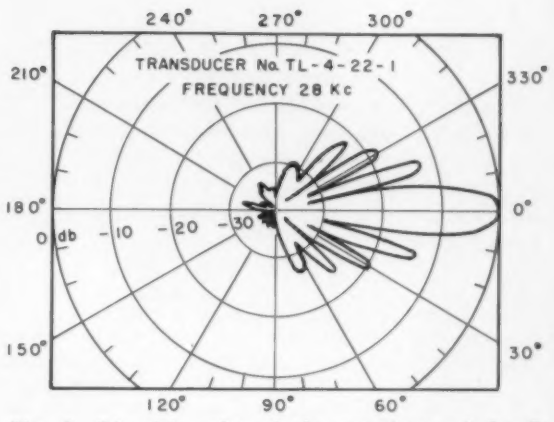
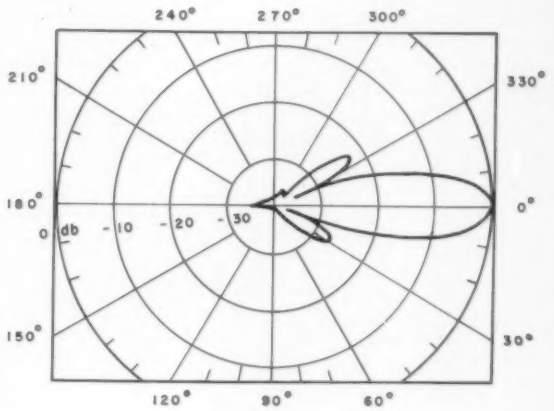


Fig. 8. Directivity plot of the transducer of fig. 7, obtained by rotating the transducer through 360 degrees.



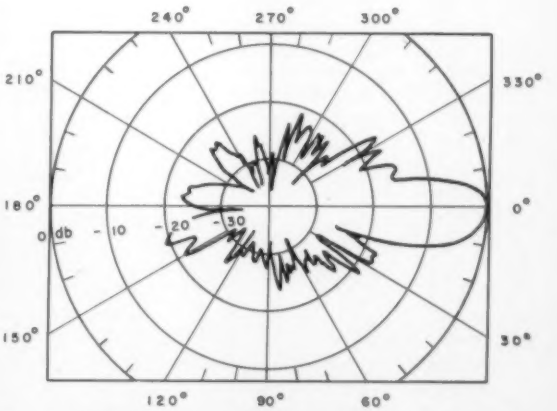


Fig. 10. Effect of sonar dome on transducer directivity. Upper illustration shows plot taken on transducer alone; lower is plot for the same transducer mounted in a dome.

Novel sound sources

Investigations are being carried out on small explosive charges and electrical sparks as sources of energy. Theoretical work indicates that such devices might be useful as broad-band acoustic sources of short pulse lengths. Experimental work is being carried out to test these conclusions.

In sonar systems mounted on surface ships, the transducer either is attached to the hull of the vessel and protrudes into the sea, or is towed behind the vessel. In both cases the transducer must be surrounded by a streamlined shape to keep the drag to a minimum and to reduce the noise due to the flow of water past the transducer. Such domes or towed bodies must be acoustically transparent and produce little distortion in the acoustic beam. However, they require considerable mechanical strength to withstand the hydrodynamic stresses, and difficulties are encountered in designing domes to meet both the acoustic and mechanical requirements. Experiments on scale models and full-sized domes and towed bodies are being carried out. Results obtained on a typical dome are shown in Figure 10. END

Hybrid parameter simplifies calculation of transistor current gain versus load

M. A. GULLEN, P.ENG.*

The computation required to construct the forward current gain versus load admittance curves of a four-terminal network is very greatly reduced if the output hybrid parameter of the network is measured. The theory is illustrated by application to a transistor.

The forward current gain of a four-terminal network, as a function of load admittance, was discussed in an earlier article in terms of the network admittance parameters (CEE, May 1959, p. 34). The mathematical expressions involved are cumbersome even when four secondary parameters, with no immediate physical significance, are introduced.

It is shown that the loci of constant magnitude and constant phase of forward current gain in the load admittance plane are circles. Centres of the two families of circles lie on two straight lines which intersect orthogonally. The line of centres of the circles of constant magnitude passes through the origin, as do all the circles of constant phase. The line of centres of the circles of constant phase is the locus of constant magnitude equal to the short circuit forward current gain, (α_{fo}).

Use of the output hybrid parameter, H_{22}, simplifies the forward current gain expressions and speeds the construction of curves. By definition, the output hybrid, H_{22}, is the output admittance of the network with an open circuit input, as distinct from Y_{22} which is measured with a short circuit input.

The forward current gain, in hybrid notation, is

$$\alpha_f = \frac{i_2}{i_1} = \frac{H_{21}\, Y_L}{Y_L + H_{22}} \quad \ldots\ldots\ldots (1)$$

When Y_L is infinite the load is a short circuit and

$$\alpha_f = \alpha_{fo} = H_{21} = \frac{Y_{21}}{Y_{11}} \quad \ldots\ldots\ldots (2)$$

In the following, H_{22} is written $g_{22} + jf_{22}$; H_{21} is written $c_{21} + jd_{21}$; the angle associated with α_f is A_f and the bracket (α_f) is used to indicate that magnitude only is considered. The tangent of the angle A_f is written p.

Constant phase loci

The equation of the locus of constant phase angle of forward current gain, A_f, in the load, (a_L, b_L) plane is

$$[a_L^2 + b_L^2]\, X + b_L\,[g_{22}K + f_{22}X] + a_L\,[g_{22}X - f_{22}K] = 0 \quad \ldots\ldots\ldots (3)$$

where $X = d_{21} - pc_{21}$ and $K = c_{21} + pd_{21}$ ...(4)

The locus is a circle and, since $a_L = b_L = 0$ is obviously a solution, all constant phase circles, independent of the value of p, pass through the origin. It can be shown that all constant phase circles intersect at one other point:

$$a_L = -g_{22}; \quad b_L = -f_{22} \quad \ldots\ldots\ldots (5)$$

The centres of the constant phase circles lie on the straight line

$$b_L = -a_L \frac{g_{22}}{f_{22}} - \frac{(H_{22})^2}{2f_{22}} \quad \ldots\ldots\ldots (6)$$

Constant magnitude loci

The equation of the locus of constant magnitude of forward current gain, (α_f), in the load plane is

$$[a_L + g_{22}]^2 + [b_L + f_{22}]^2 = \frac{(H_{21})^2}{(\alpha_f)^2}\,[a_L^2 + b_L^2] \quad \ldots.(7)$$

The locus is a circle. Centres lie on the straight line

$$b_L = \frac{f_{22}}{g_{22}}\, a_L \quad \ldots\ldots\ldots\ldots (8)$$

which passes through the origin and the point $(-g_{22}, -f_{22})$ and intersects, orthogonally, the line of centres of the constant phase circles at the point $\left(-\frac{g_{22}}{2}, -\frac{f_{22}}{2}\right)$.

If H_{22} is known, the lines of centres may be readily drawn in the load plane by:

(1) Producing the line joining the origin and the point $(-g_{22}, -f_{22})$. This is the line of centres of the circles of constant magnitude.

(2) Drawing a line orthogonal to (1) at the point $\left(-\frac{g_{22}}{2}, -\frac{f_{22}}{2}\right)$. This is the line of centres of the circles of constant phase.

Simplification of loci construction

Construction of the constant phase and magnitude circles in the load plane can be simplified by moving the origin to the point $\left(-\frac{g_{22}}{2}, -\frac{f_{22}}{2}\right)$ and rotating the axes through an angle

$$\theta_{22} = \arctan \frac{f_{22}}{g_{22}} \quad \ldots\ldots\ldots\ldots (9)$$

The new load conductance axis now coincide with the line of centres of circles of constant magnitude; the new load susceptance axis with the line of centres of circles of constant phase.

The transformation from the old axes (a_L, b_L), to the new axes (a_{Lo}, b_{Lo}) is

$$a_L = a_{Lo} \cos\theta_{22} - b_{Lo} \sin\theta_{22} - \frac{g_{22}}{2}$$

$$b_L = b_{Lo} \cos\theta_{22} + a_{Lo} \sin\theta_{22} - \frac{f_{22}}{2} \quad \ldots (10)$$

All circles of constant phase now pass through the points

$$a_{Lo} = \pm\, \tfrac{1}{2}\,(H_{22}); \; b_{Lo} = 0 \quad \ldots\ldots (11)$$

and the centre of a circle corresponding to a phase

(Continued on page 64)

*School of Engineering, Carleton University, Ottawa.

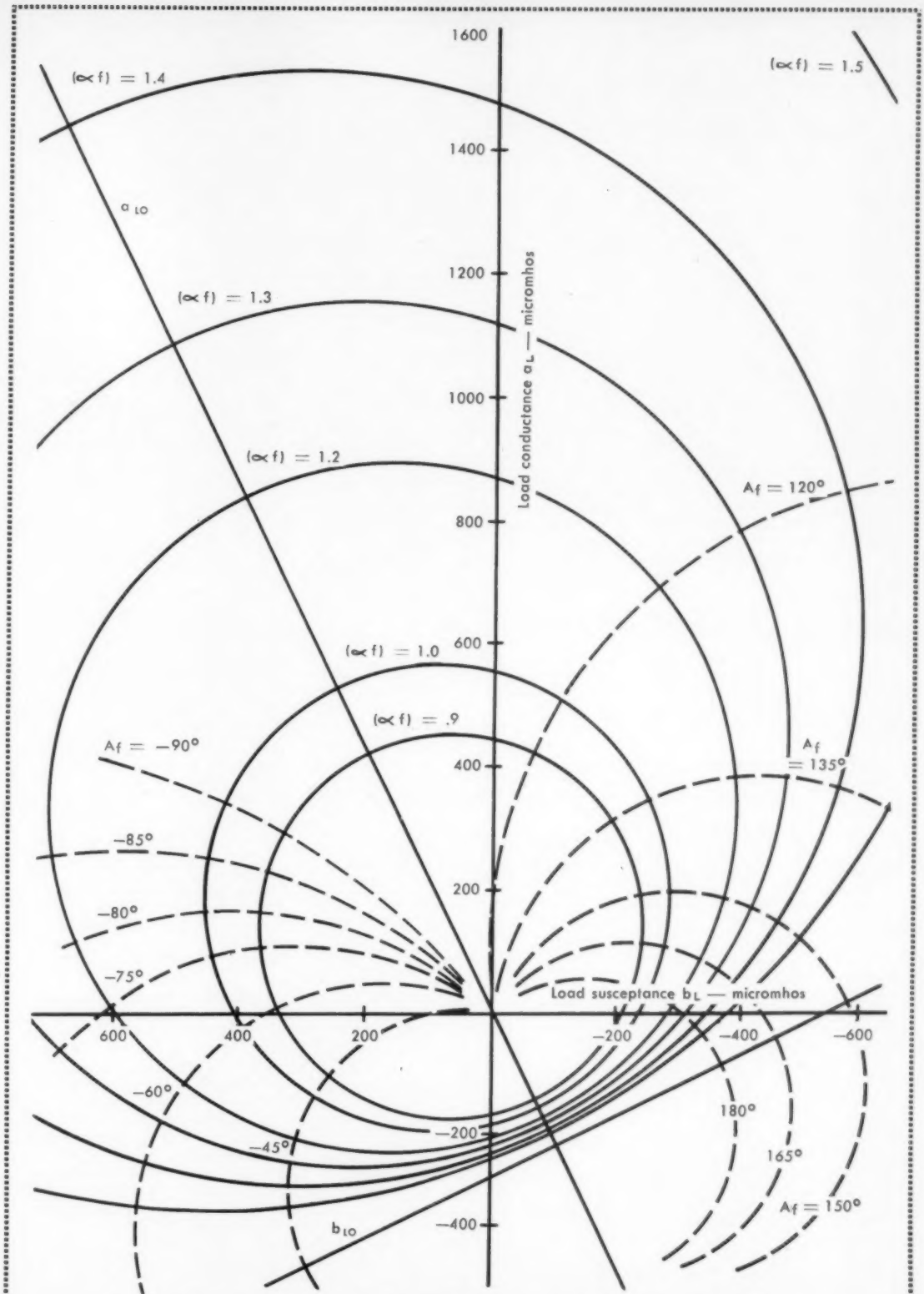


Fig. 1. Common emitter current gain versus load admittance for 2N384 transistor at 25 Mc.

For your library

Canadian author gives basics of electricity and magnetism

Electricity and Magnetism

Henry E. Duckworth; The Macmillan Co. of Canada Ltd., Toronto; 424 pp; $7.00

The author of this new book is a prominent Canadian physicist. He is editor of the Canadian Journal of Physics and Chairman of the Physics Department at McMaster University. Professor Duckworth intends this book as an intermediate text for university students who have had first courses in general physics and the calculus. Vector methods are developed, and together with the calculus, find continuous application throughout the book as a fundamental tool applied to physical problems.

The book begins with the fundamentals of electrostatics from Coulomb's Law to Laplace's Equation, and applies the theory of potentials and vector fields to a variety of problems. This leads naturally to the study of electrical capacitance, dielectrics, polarized media and the displacement currents. Direct conduction currents, including a wide range of topics on resistance, network laws, electrolysis, energy bands of semiconductors, electrical measurements, etc., are taken up next. A brief chapter on thermo-electricity presents one of the clearest expositions of the fundamentals of this subject to be found anywhere. Electromagnetism is introduced with Ampere's Law leading to the laws of electromagnetic induction, and these are applied to coupled circuits and the principles of particle accelerators. The advantages of vector notation are outstanding in this area. There follows a discussion of the magnetic properties of materials, a chapter on simple instruments, and a few examples of transient currents. The concluding two chapters introduce alternating currents using complex notation, and Maxwell's equations applied to fields.

The author has achieved his goal of providing a sound exposition of the fundamentals of electricity and magnetism for science and engineering students. Much of the confusion and mystery confronting the physics student has been removed by the consistent use of MKS units and the simplicity of the vector calculus methods. Taken with the clear and precisely written text, the result is an excellent presentation of the subject. Electronics is not included since this topic usually forms a separate study in the college curriculum. Each chapter carries graded problems with answers.

Reviewed by H. C. Ratz, Assistant Professor of Electrical Engineering, Computer and Control Systems Laboratory, University of Saskatchewan.

Catalogues and brochures

Introduction to microwave measurements: 100-page application note No. 46 presents basic information with illustrations. Hewlett Packard Co., Palo Alto. (151)

Some plain talk about closed circuit television: 20-page booklet cites examples of CCTV installations in Canada and explains function of this new industrial tool. Canadian General Electric Co. Ltd., EE&TD, Toronto. (152)

Coaxial cables for television distribution: bulletin No. 42 engineering information on distribution, service drop and main feeder cables. Northern Electric Co. Ltd., Montreal. (153)

Semiconductors for industry and communications: issue No. 3 of the Rogers Catalogue of transistors and diodes. Rogers Electronic Tubes and Components, Toronto. (154)

Unimax precision switches: 32-page catalogue No. 10-1 contains information on snap-acting precision switches. Aeromotive Engrg. Products Ltd., Montreal. (155)

Heat-dissipating electron tube shields: 22-page catalogue from IERC contains information on shields for subminiature tubes. R-O-R Associates Ltd., Don Mills, Ont. (156)

Oscilloscopes and associated instruments: abridged 15-page catalogue from Tektronix, Inc., Willowdale, Ont. (157)

Cable marking systems, cable clips and straps, terminal blocks and strips are described in 12-page catalogue from Electrovert Ltd., Montreal. (158)

Zener protection circuits for aircraft voltage surges: 4-page application notes from Canadian Motorola Electronics Ltd., Toronto. (159)

What you should know about stand-off fasteners is an 18-page booklet containing useful information on fasteners used to support tubing, wire bundles, instruments, etc. Western Sky Industries, Hayward, Calif. (160)

Silicon and selenium rectifier data describes the complete "Certified" line of rectifiers from Syntron (Canada) Ltd., Stoney Creek, Ont. (161)

Waveguide components and test equipment catalogue describes Microwave Associates products. E. G. Lomas, Ottawa. (162)

Selector switches are listed in 4-page catalogue from CTS of Canada Ltd., Streetsville, Ont. (163)

Microphones and accessories, high-fidelity components, magnetic recording heads and phono cartridges are described in Shure catalogue No. 60A. A. C. Simmonds & Sons Ltd., Toronto; C. M. Robinson Co. Winnipeg. (164)

Semiconductors: 24-page short form catalogue covers over 800 semiconductor devices from International Rectifier. Douglas Randall (Canada) Ltd., Toronto. (165)

Phono drives, replacement transformers, tools, chemicals and other service products from Walsco are listed in 68-page catalogue. Atlas Radio Corp., Toronto. (166)

Rigid coaxial transmission lines and associated equipment; catalogue CR. Andrew Antenna Corp. Ltd., Whitby, Ont. (167)

Communications equipment and instruments are described in the Racal general catalogue for 1960. Instronics Ltd., Stittsville, Ont. (168)

Panel meter catalogue contains 24 pages of information on DeJur electrical indicating panel instruments. Atlas Instruments Corp., Toronto. (169)

Transistor guide for switching circuit designers provides information on switching transistors. Philco Corp. of Canada Ltd., Toronto. (170)

Sheet metalworking machine, the Strippit Super 30 for prototype and short run production metal punching is described in catalogue 30S. Strippit Tool and Machine Co., Brampton, Ont. (171)

Linguatrainer electronic language laboratory system is explained in 6-page brochure. Stark Electronic Sales Co., Ajax, Ont. (172)

Silicon semiconductor devices are the subject of brochure FSD3560. Ferranti-Packard Electric Ltd., Toronto. (173)

Readout fact finder is a 16-page brochure showing details of major types of in-line readouts. Burroughs Adding Machine of Canada Ltd., Toronto. (174)

Fast pulse transmission equipment, useful with nanosecond rise time square pulse generators and other fast pulse sources, is described in a 5-page bulletin. Electrical and Physical Instruments Corp., Long Island City, N.Y. (175)

Metal-ceramic trimmer resistors series 170 and 180 are described in data sheets 178 and 177 respectively. CTS of Canada Ltd., Streetsville, Ont. (176)

Instrument maintenance sessions to precede ISA Toronto conference

A group of maintenance clinic sessions will be held in Toronto June 3 and 4, 1961. They will be held in conjunction with, but preceding, the 1961 Summer Conference and Exhibit of the Instrument Society of America at Toronto.

The summer conference, scheduled for June 5-8, will provide a forum for approximately fifty technical papers, presented in sixteen sessions keyed to the various areas of instrumentation and to the major industries employing instruments. There will be a special program of particular interest to management and senior engineering personnel.

The technical sessions and associated functions will be held in Toronto's Royal York Hotel. Exhibits will be displayed in the Queen Elizabeth Building, Exhibition Park.

The aim through the proceedings will be to present the broad picture of instrumentation developments and available equipment from Canada, the United States and abroad.

General chairman of the conference is J. R. Rogers of the Bristol Company of Canada Ltd., and the committees are under the direction of the executive chairman, J. Pefhany of Orenda Engines Ltd. Enquiries may be directed to their attention directly or c/o 970 Lawrence Ave. W., Toronto 19, Ont.

Productivity fair

The National Industrial Production Show of Canada to be held at the Canadian National Exhibition Park, Toronto, May 8th to 12th, 1961, has assumed the importance of a National Productivity Fair.

Besides equipment at the Production Show, there will be technical discussions of methods, by sponsoring societies. One of the sponsors, The American Society of Mechanical Engineers, Ontario Section, formed what will be known as the Canadian Production Engineering Division, A.S.M.E. It has arranged for a joint conference in Toronto during the Show with the corresponding Production Engineering Division of the A.S.M.E. in the U.S. There will be prominent speakers from both the United States and Canada, and possibly Great Britain. Dr. Alan Hogg, Research Engineering Manager of the Ontario Hydro is arranging the Canadian program, and Dr. A. O. Schmidt, of Milwaukee, the American.

At a subsequent meeting in New York City with executives of the parent Society it was decided to adopt as general theme for the joint Production Engineering Conference: "International Cooperation For Productivity." This could be paraphrased as automation methods in modern production. It will be a study of the most recent developments in control media for machine tools and production equipment. There will be panel discussions also on metal processing. Efforts are being made to set up standards of automatic controls between countries and between firms.

Production methods will be discussed also by two other sponsors, namely, The Canadian Welding Society and the Canadian Industrial Management Association: They are now working on programmes and arrangements.

Nuclear association conference

Ian F. McRae, President of the newly formed Canadian Nuclear Association announces that the first annual meeting and conference of the Association will be held in Toronto on May 16th and 17th, 1961, at the Lord Simcoe Hotel.

On the agenda will be prominent speakers from the U.S. and Canada who are engaged in the research, development or utilization of the peaceful uses of nuclear energy and radio isotopes.

It is anticipated that approximately 250 members and others will attend.

Quality control forum

The Toronto Section of the American Society for Quality Control will hold their eighth annual All-Day Quality Control Forum on Saturday, March 11, 1961 at Hart House, University of Toronto. Information may be obtained from J. E. Boardman, Honeywell Controls Ltd., Vanderhoof Avenue, Toronto 17, Ont.

Instrumentation clinics

The Toronto Section of the Instrument Society of America is offering, for the first time, a series of Instrumentation Clinics. These will be 'shirt-sleeve' sessions during which instruments and control equipment will be used to demonstrate the operation, servicing and application of each item. This will be popular with those anxious to improve their familiarity with instruments and controls in a practical way.

The clinics will include pneumatic, electronic and electrical instrumentation presented, primarily, by member companies. They will present talks using demonstration equipment, supply technical data, servicing information and application notes. Binders will be supplied to registrants in which information may be retained.

This group of about five sessions will be available at an entrance fee of $3. A copy of the ISA Industrial Instrument Mechanic Training Course will be supplied free to ISA member registrants ($1.50 to non-members). Films will be used, and where ISA films with printed texts are employed, the texts will be supplied free to ISA members ($1.25 to non-members).

In addition to the new program of instrumentation clinics, education courses in instrumentation fundamentals and control system analysis are also being offered.

For further information call J. Paluch, Consumers Gas Co. Ltd., EM 2-5858, Ext. 432 regarding the instrumentation clinics. Call J. Raycroft, Honeywell Controls Ltd., HU 9-2151 regarding the education courses. Readers may also write to ISA, c/o 970 Lawrence Ave. W., Toronto 19.

IRE Section meetings

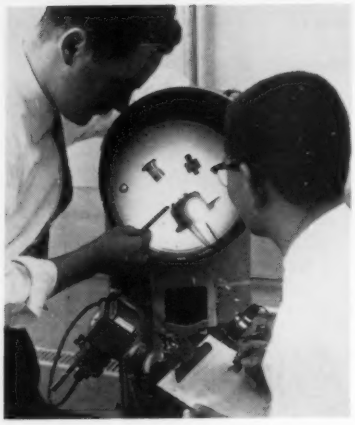
Kitchener - Waterloo: Feb. 20; "Some problems in the development and production of antennas," by Dr. W. V. Tilston, Sinclair Radio Labs. Ltd.; University of Waterloo, 8.15 p.m.

Ottawa: March 2; "Developments in microwave tubes at Canadian Marconi Laboratories," by A. Cutting and D. F. Osborne; NRC Auditorium, Sussex Dr.; 8.15 p.m.

Toronto: Feb. 16; Students' Night. Joint meeting with AIEE Toronto Section and student branches for student papers competition. Electrical Bldg., U. of T., 8.15 p.m. AIEE supper club (others invited) will have film and talk by R. Robinson, CGE, on "Toshiba in progress"; reservation deadline is Feb. 14, telephone Mr. Chackeris, EM. 3-2261, Ext. 389.

Feb. 27; "Canadian topside sounder satellite," by Dr. R. C. Langille, DRTE, Ottawa; joint meeting with Canadian Astronautical Society at main cafeteria, de Havilland Aircraft of Canada Ltd., 8 p.m.

New components



Tunnel diodes 101

Two new tunnel diodes are under development at IBM. One has a switching time of less than 0.4 nanosec. The other is in an earlier stage of development, but in intended for use in computer storage circuits. Fabrication of both diodes uses an etching technique which takes place after the germanium has undergone its basic device packaging. The picture shows "rivet" and "micro-wedge" packages alongside a diode mounted in a conventional package.

International Business Machines Co. Ltd., Toronto.

General-purpose accelerometer 102

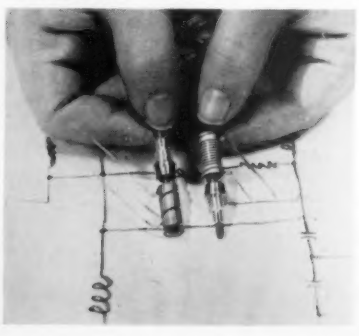
Model EM900 general-purpose piezoelectric accelerometer has a range of 0.05 to 10,000 G's and can measure vibration up to 10 kc with no measurable hysteresis observed. Sensitivity is 15 millivolts peak per G peak. It can be operated in ambient temperatures ranging from —100 F to +500 F. The mounting stud is mechanically isolated to eliminate distortion in the accelerometer.

Raytheon Canada Ltd., Waterloo, Ont.

Stable tunable inductors 103

Eleven models of a small, stable, tunable inductor have been standardized for application in airborne high frequency communications equipment. The 11 models have a nominal inductance range of 0.03 to 0.40 microhenries, with an adjustment range of approximately ±10%. Minimum Q ranges from 120 to 220, depending on frequency and inductance value. With brass core retracted, temperature co-efficient is approximately ±10 ppm/deg. C over an operating range of —55 C to +125 C. Ideal operating characteristics lie between 10 and 250 Mc.

Corning Electronic Components, Bradford, Pa.



Nameplates 104

Sub-surface printing and metalizing protect printed information on these new Mylar name plates. The legend cannot be removed by abrasion. Application is by self-bonding PSA-ZOL type adhesive, protected until time of use by a zip-off liner.

W. H. Brady Co. of Canada Ltd., Brampton, Ont.

All-metal delay lines 105

The new 8810 series Helidel delay lines are continuously variable distributed constant units which afford precise selection of short time intervals. Delay times of 1 usec to 0.1 usec are provided, with rise time less than 10% of total delay time. All models have an ambient temperature range of —55C to 80C, and life expectance of one million or more shaft revolutions.

Helipot Div. of Beckman Instruments, Inc., Toronto.

Micro-diodes 106

High temperature glass is melted directly around these diodes to assure a hermetic seal. First units offered are eight types of voltage regulators with operating and storage temperatures of —55C to 150C; maximum power dissipation at 25C is 100 mw; Zener voltage is between 5.1 volts and 10 volts at 5 amperes.

Transitron Electronic Sales Corp., Toronto.

Relay sockets 107

Viking industries has introduced an improved version of their microminiature sockets for industrial and military use. They feature rear entry, crimp type contacts which meet applicable requirements of MIL-C-26636.

Douglas Randall (Canada) Ltd., Toronto.

(Continued on page 60)

New instruments

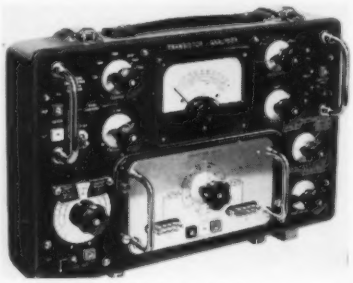
Recorder controller 108

A single-case time-program recorder-controller is now offered in the Series 500 instrument line. The recorder chart and the program cam are independently driven making it possible to record repetitions of the program on a single chart. The program time may be from 30 minutes to 30 days. Various models of the instrument measure and control temperature, pressure, flow, liquid level and humidity. Either pneumatic or electronic control is offered.

The Bristol Co. of Canada Ltd., Toronto.

Transistor analyzer 109

AVO transistor analyzer is a direct reading instrument capable of giving measurements in the grounded emitted configuration. Designed primarily for testing signal and low power transistors, it can also test high power and switching types with the use of adapters. The instrument may be used for individual



and batch testing, or in-situ measurements.

R. H. Nichols Ltd., Toronto.

Industrial infrared pyrometers 110

Model 1372 Servotherm industrial radiation pyrometer for permanent installation or portable use, provides non-contact control to an accuracy of ±1%. The infrared optical system covers the industrial wavelength spectrum from 1 to 12 microns. Range is 120 F to 2,800 F (50 F to 10,000 F with accessories). The sensing head is mounted on a tripod for portable use, and the amplifying and control units are all enclosed in the control cabinet.

Servo Corp. of America, Hicksville, L.I., N.Y.

Tube testers 111

B&K Model 685 Dyna-Quick dynamic mutual conductance tube tester features the speed of multiple socket testing for existing tube types, plus the flexibility of punch card testing for new types which may be introduced on the market. It tests each section of multiple tubes separately, checks for Gm and shorts,

New equipment

makes grid emission and gas test, checks for leakage and life, gives heater continuity test for series filament sets, and shows tube condition on a meter. Blank Dyna-Cards, hand punch and tube card information service are included with the instrument.

Model 610 Test Panel (available in three models) extends the range of existing B&K tube testers models 500, 550 and 650 to permit testing of new tube types.

Atlas Radio Corp. Ltd., Toronto.

High-frequency meters 112

Yokogawa Electric Works high frequency thermocouple milliammeters and voltmeters model TPF are available in four ranges: 5 ma to 1,000 ma, 15 volts to 150 volts. Accuracy is rated at ½% fsd for voltmeters and 1% for milliammeters. Frequency error is 1% from dc to 5 Mc. An adjusted spare vacuum thermocouple is provided.

Stark Electronic Instruments Ltd., Ajax, Ont.

Transistor oscillator 113

The new Solartron RC oscillator CO 1008, based on an original design by the Royal Radar Establishment, covers a frequency range of 20 cps to 200 kc. Frequency may be set to an accuracy of ±5% with the fine control dial, and is held to within 0.2% of the set frequency over an 8 hour period. The output, which is continuously variable up to 1 volt amplitude, contains less than 0.25% total harmonic distortion above 100 cps and less than 1% below 100 cps. The oscillator uses the virtual ground technique employed by computing amplifiers to provide very stable characteristics. Frequency control is by resistive tuned Wien network and amplitude stability of ±2% is achieved by thermistor feedback.

Instronics Ltd., Stittsville, Ont.

Rugged oscilloscope 114

Model 170A oscilloscope is designed for general purpose measurements in both military and commercial applications. It meets the requirements of MIL-E-16400 and other military specifications for shock, vibration, humidity and temperature effects. In addition to accepting plug-in vertical amplifiers such as the model 162A dual trace amplifier with up to 20 mv/cm sensitivity and 14 nanosecond rise time, Model 170A has provision for a series of time axis plus-in units which enhance its versatility. These units include the model 166C display scanner, which provides the scope with an X-Y recorder output.

Hewlett-Packard Co., Palo Alto, Calif.

(Continued on page 62)

Light valve projector 115

This projector uses an electronic projection system to produce screen displays up to 50 feet wide with normal room lighting. It will accept an input of processed data or TV signals. A control layer modulates the light from a high intensity xenon lamp. The optical characteristics of the control layer are changed by a beam from an electron gun which is controlled by the input signal.

Canadian General Electric Co. Ltd., Toronto.

Power supply 116

Viking model 101-D solid state power supply features 0.1% regulation for any combination of input voltage or load conditions. Ripple is less than 1 mv RMS. Input is 100 to 130 v, 50 to 2,000 cps. Temperature stabilization insures a maximum of ±0.01% per deg. C drift. An output of 12 vdc at 1 ampere is available over a temperature range of —25C to +45C and is capable of operation up to +71C at reduced output current.

Douglas Randall (Canada) Ltd., Toronto.

Multi-point temperature controller 117

This multi-point temperature controller provides automatic two-position control for up to ten separate processes. The instrument can also be used as a single point controller, a five-point three-position controller and a manual-balance indicator. Any points not being used for control of a multi-temperature process, can monitor other processes. It combines a sensitive null-balance potentiometer measuring circuit with an electronic control system and is adaptable to any installation requiring off-on control. Accuracy is 0.5% of range.

Thermo Electric (Canada) Ltd., Brampton, Ont.

Private telephone 118

Stromberg-Carlson Dialmaster model TSB-100 is a completely automatic telephone switchboard designed to provide internal communications for business and industry. Equipped with 14 links, the switchboard can serve as many as 100 telephones on a private-line basis. Standard features include group hunting, conference service and executive right-of-way.

Hackbusch Electronics Ltd., Toronto.

Automatic terminaling machine 119

Instant adjustment of swaging terminals to any of six wire sizes with any of twelve insulation diameters is accomplished by a simple, one-hand setting of the double-deck, concentric selector dial of the model 61 terminaling machine. To compensate for variations in stranding, the wire dial can be set at intermediate points.

Ark-Les Switch Co., Watertown, Mass.

Portable transmitter receiver 120

Northern Radio's new N414 series of portable MHF transmitter-receivers is available for either single-channel or six-channel operation in the band from 2 to 13 Mc. The single unit houses a 36-watt transmitter and a receiver with a sensitivity of 2 uv; weight is less than 13 pounds; size is 6x14½x5 in. It

operates from a 12 vdc source and is supplied with microphone and speaker in a rain-proof carrying case.

Tele-Radio Systems Ltd., Toronto.

(Continued on page 65)

Materials—continued

lined above. Intermediate devices using supporting structures with somewhat lower stability but offering the advantages of better performance have been developed. Also, we are developing products utilizing thermoelectric elements, such as reference junctions for thermocouple work, laboratory coolers for use where solution temperatures must be maintained at or below ambient temperatures, and thermocouple cooled baffles for vacuum pumps. Descriptions of these devices are given elsewhere in this series of articles. END

Hybrid—continued

angle A_f has coordinates

$$a_{Lo} = 0; \quad b_{Lo} = -\tfrac{1}{2}(H_{22}) \operatorname{cotan} [\theta_{21} - A_f] \quad \ldots\ldots(12)$$

where $\theta_{21} = \arctan \dfrac{d_{21}}{c_{21}}$ $\ldots\ldots(13)$

and is the angle associated with α_{fo}, H_{21}.

The centre of a circle of constant magnitude of forward current gain equal to (α_f) has coordinates

$$a_{Lo} = \tfrac{1}{2}(H_{22}) \frac{[(H_{21})^2 + (\alpha_f)^2]}{[(H_{21})^2 - (\alpha_f)^2]}; \quad b_{Lo} = 0 \quad \ldots(14)$$

and a radius

$$R = \frac{(\alpha_f)\ (H_{22})\ (H_{21})}{[(H_{21})^2 - (\alpha_f)^2]} \quad \ldots\ldots\ldots(15)$$

The difference between the a_{Lo} centre coordinate and the radius is

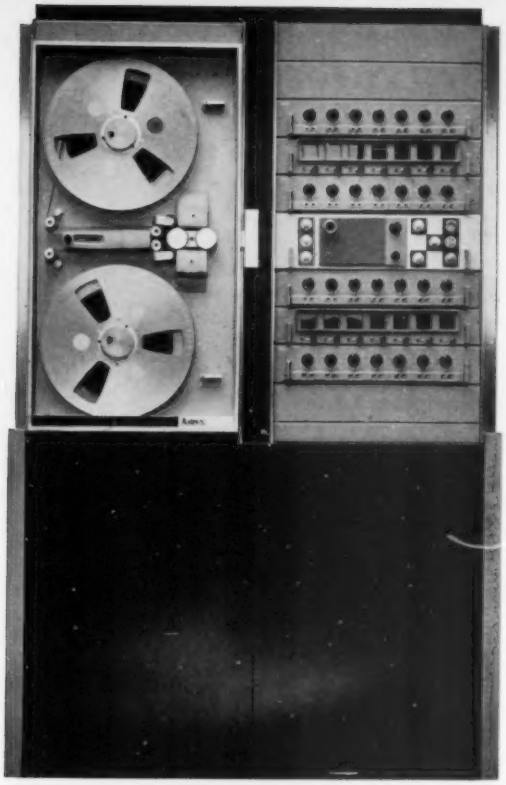
$$D = \tfrac{1}{2}(H_{22}) \frac{[(\alpha_f) - (H_{21})]}{[(\alpha_f) + (H_{21})]} \quad \ldots\ldots(16)$$

which vanishes, as expected, when $(\alpha_f) = (\alpha_{fo}) = (H_{21})$.

Application

The forward current gain versus load admittance curves of a 2N384 transistor at 25 Mc, common emitter configuration, are shown in Figure 1. H_{21e} of the sample at this frequency is 1.82 at an angle of minus 102 degrees. END

"As well as the high power radio transmitter, we have to include a television relay, infrared scanner, radar telescope, and all the other equipment on this list."



The AMPEX FR-600 is an advanced-design data recorder with twice the capacity of conventional recorders. Most analog recorders can only record 24 minutes of 100 Kc data on a 14-inch reel of 1 mil tape. The FR-600 will record 48 minutes of the same data on the same reel of tape. The reason – greater bandwidth at a given speed . . . 125 Kc at 30 ips, for example. Many data-runs are 30 minutes or longer, requiring a stand-by recorder to pick up where the first leaves off . . . an expensive price for a few extra minutes of recording time. The FR-600 literally does the work of two conventional machines by enabling double record time for any given bandwidth, or double bandwidth for any given record time . . . 250 Kc at 60 ips, for example. Another cost-saving feature is the tape shuttle which automatically scans any portion of the tape, eliminating the need for a separate loop recorder. Modular plug-in, solid-state electronics warm up in less than 10 minutes, and FM amplifier drift is less than one percent in 24 hours. Other advanced features of the FR-600 include pneumatic tape guiding, tension sensing and control, adjustable search speed and fourteen miniature monitor oscilloscopes. For complete information write Ampex of Canada Ltd., 607 Commonwealth Bldg., Ottawa, Ontario. AMPEX

For further information mark No. 11 on Readers' Service Card

People—continued

here in Canada and, in 1959, was chairman of the United Nations Technical Committee on Outer Space. He is also the Canadian representative on the International Committee on Space Research (COSPAR) established by the International Council of Scientific Unions. During the International Geophysical Year, 1957-58, Dr. Rose was chairman of the Co-ordinating Committee of the Canadian program. In 1954, Dr. Rose carried out a major research mission as head of a party of scientists on HMCS Labrador sailing through the North-West Passage.

John F. Hooper promoted to manager—mobile sales and Gust Landstrom to assistant manager—mobile sales at Canadian Motorola Electronics Ltd.

Hooper

Landstrom

Formerly Ontario Region sales manager, Mr. Hooper assumes responsibility for coast-to-coast sales of all Motorola mobile communications equipment. He will remain at the firm's Toronto headquarters in his new capacity. Mr. Landstrom was formerly sales representative in Ontario.

T. R. McLagan and R. E. Morrow have been elected directors of Sperry Gyroscope Co. of Canada Ltd.

Mr. McLagan is president of the Canadian Manufacturers' Association and of Canada Steamship Lines Ltd. He is also a director of Abitibi Power and Paper Co. Ltd.; General Dynamics Corp., New York; Royal Bank of Canada; and a number of other well-known companies.

Mr. Morrow is a partner in a Montreal law firm. He is a director of Anglo - Newfoundland Development Co. Ltd., as well as a number of other Canadian Corporations.

B. W. King, managing director of Sperry Gyroscope, said that the election of the new directors was an extension of the company's continuing program of Canadianization.

APEO elects president and councilors for 1961.

A 47-year-old Saskatchewan-born mechanical engineer, **Lawrence C. Sentance** of Burlington, has been elected president of the 20,000-member Association of Professional Engineers of Ontario. Mr. Sentance is manager of the Defence Apparatus Division of Canadian Westinghouse Co. Ltd., Hamilton.

Elected as councilors in the electrical branch of the APEO are: **M. J. McInroy,** sales service manager, Automatic Electric Sales (Canada) Ltd., Toronto; and **E. G. Phillips,** research department, Ontario Hydro, Toronto. The appointed representative is **H. R. Sills** of Peterborough.

Automatic Electric Sales (Canada) Ltd. appoints L. A. Haizelden and W. D. Bishop to sales posts in Industrial Products Division.

Bishop

Haizelden

Mr. Haizelden is appointed as relay sales specialist. Mr. Bishop is a sales representative, specializing in TelAutograph telescribing equipment and in industrial closed-circuit television systems. Both are located at the head office in Toronto.

Bruce Emonson has been appointed vice - president of TelePrompTer of Canada Ltd.

Mr. Emonson has been associated with TelePrompTer of Canada (a division of S. W. Caldwell Ltd.) for a number of years, most recently as manager, and has been responsible for many noteworthy closed-circuit telecasts for leading Canadian companies. He has also supervised the sale of TelePrompTer electronic prompting devices.

Reports—continued

Molecular Electronics Inc., New York, N.Y. (transistor frequency response meters).

Stratham Development Corp., Los Angeles, Calif. (temperature test chambers).

AAAS presents major award to Bell Telephone Labs.

The American Association for the Advancement of Science has presented its annual "Industrial Science Achievement Award" to Bell Telephone Laboratories, Inc. The citation referred to the Laboratories' achievements in the field of universal communication during 1960.

Previous winners of the award have included General Electric Co. (1956), P. R. Mallory Co. (1957), and Westinghouse Electric Corp. (1958).

More U.S. firms represented in Canada

Bud Radio, Inc., Cleveland 3, Ohio, are now represented in Canada by **A. T. R. Armstrong Ltd.,** Toronto (components, sheet metal products, special fabrications).

Radionics Ltd., Montreal, was recently appointed exclusive Canadian representative of Electro-Pulse, Inc., Los Angeles, Calif. (single and double pulse generators; word, pulse train and pulse code generators; time delay and gate generators; current generators; core testers; measuring instruments).

Bayly Engineering Ltd., Ajax, Ont., is now the Canadian representative for Carpenter Mfg. Co., Detroit, Mich. (power driven wire stripping machines).

Lake Engineering Co. Ltd., Scarborough, Ont., has been appointed a stocking distributor as well as sales representative for Garlock, Inc., Camden, N.J. (molded, extruded and machined plastic products).

R-O-R Associates Ltd., Toronto, Ottawa and Montreal, has been appointed exclusive Canadian representative for Bourns (Canada) Ltd., Scarborough, Ont. (Trimpot and linear motion potentiometers, pressure and acceleration transducers).

CGE completes major order for two-way radio

The electronic equipment department of Canadian General Electric Co. Ltd., has completed delivery of 46 two-way mobile radio sets and equipment for 20 base stations to Trans Canada Pipe Lines Ltd.

Trans Canada is using the CGE equipment in the operation and maintenance of its transcontinental gas pipe line, over a 500-mile stretch of the line between Winnipeg and the Alberta/Saskatchewan border.

Including its communications facilities in other sections of the line, now operated on a rental basis, Trans Canada has one of the largest two-way radio systems in the country.

Ottawa report

Watch for changes in the regulations governing the distribution of Vote 71 of the Defence Production Department used to assist the electronics and allied industries.

Defence Production Minister Raymond O'Hurley said in an interview, "We know the electronics industry is having trouble. We have received requests on Vote 71 and these are being considered."

Vote 71, first set up in 1959, comprises a fund of $5 million designed to "sustain technological capability in Canadian industry." Grants are made, most often on a 50-50 basis, to individual companies to assist in development work on specific projects for which a known market exists.

The $5 million sum remains unchanged from the 1959-60 fiscal year but in addition this year the department has authority to make commitments for future work for another $7 million.

Complaint of the industry is that current regulations covering the distribution of the funds are too restrictive. The Electronic Industries Association of Canada, in its recent brief to the cabinet in Ottawa said: "It is recommended that the criteria for expenditures of funds under Vote 71 be revised to provide immediate assistance to the development of new products in order to maintain the capability in Canadian companies for the penetration of all electronics markets. Such expenditures need not be related to the securing of definitive contracts but rather to the general development of technological capability in the industry."

Reliable sources report that this is exactly what the government intends to do this year. The amendments, likely in the spring at budget time, would enable the grants to be made for general research and development work rather than being tied to projects for which immediate markets can be foreseen.

Currently close to $4 million of the $5 million in the fund has been allocated. Sources report that if firm demands are made the $5 million ceiling for this fiscal year would be lifted. In addition, there is a strong probability that the fund will be substantially increased for the next, 1961-62, fiscal year.

Are you looking for ways to reduce the expenses of labor turn-over, absenteeism and industrial injuries? Then hire older workers, reports the Labor Department in a special survey.

And it has the figures to prove it:

—Separations among those under 45 are 62 per 100 employees; among those over 45 they are down to 38 per 100.

—Absenteeism in the 20-35 age group averages 4.3 work-days in each 100; for those in the 45-60 group it drops to 3.2 days.

—Industrial injuries in the 20-35 age group average 1,500 per million work-hours; this compares with 770 for the 45-60 age group.

The Commons Special Committee on Research has held its first, informal, meeting to map out a program for this session of parliament.

Regular hearings will begin this month, it is learned. First item to be studied will be the National Research Council, held over from last summer's session. Particular emphasis will be given this time to the relationship and extent of co-operation between NRC and industry, the universities and provincial research institutions.

Following the hearings on the NRC the committee, chaired by J. W. Murphy (PC—Lambton) will consider the activities of Atomic Energy of Canada Limited and it hopes to throw some light on controversies about the government's nuclear power program.

CAMESA News

This bulletin has been prepared for CEE by the Specifications and Electron Devices Divisions, Canadian Military Electronics Standards Agency, Ottawa.

▸ Specification **MIL-S-20708A** covering 60- and 400-cycle synchros has been issued recently. The principal changes appearing in this issue are clarification of several test procedures, an increase in the altitude requirement from 70,000 to 100,000 feet, and revision of the electrical parameters of many of the synchros covered by the detail specifications. The method of expressing tolerances on many of the electrical parameters has also been changed.

▸ Specification **MIL-C-11272B** covering fixed glass dielectric capacitors has been issued recently. Many changes have been incorporated in this issue including temperature range, capacitance tolerance and insulation resistance. Medium impact shock, high frequency vibration and solderability tests have been added, and the low frequency vibration test has been deleted. Eight new styles of vitreous enamel capacitors have been added.

▸ Specification **MIL-M-10304B** covering panel-type ruggedized meters will be issued shortly. Principal changes include the addition of two 1½-inch square flange meters, one 4½-inch round flange meter, and one 3½-inch round flange decibel meter. All 2½-, 3½- and 4½-inch meters must now be provided with external zero adjusters.

▸ Specification **MIL-M-6B** covering panel-type meters has been withdrawn in the U.S.A. and will shortly be withdrawn for Canadian procurement. Future procurement should be made under Specification **MIL-M-10304B.**

Silicon voltage regulator diodes

▸ At present a wide variety of regulator diodes are being used in military equipments and this is causing quite a logistics problem. Although none of these devices appear in our Preferred and Guidance lists at present, we are now in a position to make recommendations for military use.

▸ The military have agreed on the following plan for the standardization of these devices:

Dissipation	Recommendation
Up to 400 mw	Use 400-mw double-ended type in subminiature glass package.
Up to 1 watt	Use 1-watt double-ended lead mounted in cylindrical package.
Up to 10 w	Use 10-watt stud-mounted type.
Up to 50 w	Use 50-watt diamond flange-mounted type.

In each range the Zener Voltage (Vz) values follow the EIA 5% number series, and the tolerance on Vz is ±5%.

▸ Within the above framework we are currently recommending the following types:

400 mw

1N746A-758A to MIL-S-19500/127 (Navy). Vz range: 3.3 v to 10 v.

1N962B-992B to MIL-S-19500/117 (Navy). Vz range: 11 v to 200 v.

1 watt

1N3016B-3051B to MIL-S-19500/115A (Navy). Vz range: 6.8 v to 200 v. Case: 0.350 in. x 0.225 in. dia.

10 watts

1N2970B , RB - 3015B,RB (omit-

ting 1N2978, 2981, 2983, 2987, 2994, 2996, 2998, 3006, 3010, 3013B and RB, which do not fall within the 5% number series). Specification: MIL-S-19500/124(Sig C). Vz range: 6.8 v to 200 v. Case: JEDEC DO-4.

1N1804 to MIL-E-1/1236(Sig C). Vz = 6.2 v. Case: Similar to DO-4, but slightly larger.

50 watts

1N2804B, RB-2846B, RB (omitting 1N2812, 2815, 2817, 2821, 2828, 2830, 2839B and RB). Specification: MIL-S-19500/114 (Navy). Vz range: 6.8 v to 200 v. Case: JEDEC TO-3.

Defence contracts

Unclassified electronics contracts for $10,000 or more have been awarded to the following Canadian firms by the Department of Defence Production. A figure in parentheses indicates the number of contracts, the amount being the total value.

December 1-15, 1960

- Ampex of Canada Ltd., Ottawa, magnetic tape recording systems and accessories, $49,176 (2).
- Aviation Electric Ltd., Montreal, preproduction phase of registering accelerometers, $122,014.
- British Columbia Telephone Co., Vancouver, rental of telephone facilities, $32,970 (2).
- Canadian Marconi Co., Montreal, signal generators, $153,055 (4).
- Computing Devices of Canada Ltd., Ottawa, aircraft instruments and navigation equipment, $2,357,800.
- De Havilland Aircraft of Canada Ltd., Downsview, Ont., antenna modules, $24,900.
- E. P. Electric Products Co. Ltd., Montreal, components, $10,243.
- Electronics Materiels International Ltd., Ottawa, cable assemblies, $13,189; headsets, $13,094.
- Radionics Ltd., Montreal, equipment, $18,075.
- Tellurometer Canada Ltd., Ottawa, distance measuring equipments, $103,393 (2).

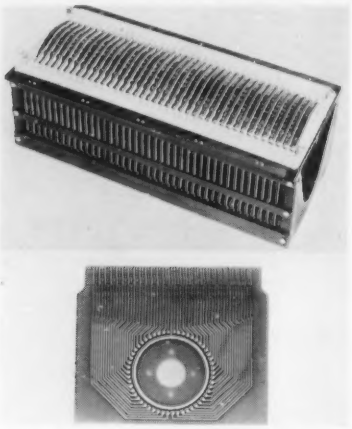
December 16-31, 1960

- Ampex of Canada Ltd., Ottawa, tape transport, $13,694.
- Canadian Curtiss-Wright Ltd., Toronto, ultrasonic cleaners, $21,719.
- Canadian General Electric Co. Ltd., Toronto, pre-production engineering for electronic test equipment for aircraft, $993,147.
- Collins Radio Co. of Canada Ltd., Toronto, antenna, $16,851.
- Computing Devices of Canada Ltd., Ottawa, test equipment for position and homing indicators, $346,857.
- Allan Crawford Associates Ltd., Willowdale, Ont., equipment, $16,612.
- Honeywell Controls Ltd., Toronto, test equipment for automatic flight control systems, $4,199,250 (2).
- Lenkurt Electric Co. of Canada Ltd., Vancouver, spares for multiplexing equipment, $18,135.
- Litton Systems (Canada) Ltd., Rexdale, Ont., ground support equipment for navigation system, $1,666,325.
- National Telecommunication Supply Ltd., Ottawa, installation of beacon, $15,239.
- Northern Electric Co. Ltd., Montreal, fire alarm switchboard, $11,568; spares for field test equipment, $50,000; teletype spares, $128,527.
- RCA Victor Co. Ltd., Ottawa, equipment, $38,187 (2).
- Ray-O-Vac (Canada) Ltd., St. James, Man., batteries, $12,210.
- Sperry Gyroscope Co. of Canada Ltd., Montreal, tubes, $22,824; compass, $23,277.
- Standard Telephones & Cables Mfg. Co. (Canada) Ltd., Montreal, transmitters, $91,770 (2); transmitting equipment, $200,176 (2); installation of beacon, $20,564.
- TMC (Canada) Ltd., Ottawa, transmitter equipment, $308,697 (2).

New equipment—cont.

High capacity data switch 121

Printed circuits and modular construction have been used in this compact, high capacity data switch for multi-contact temporary or permanent switching. The model shown in the photograph has 40 single-pole switches, each of which can be manually positioned to select one of 56 contacts on



glass fibre laminated printed circuit boards. Output taken from a printed circuit at the rear can be provided with auxiliaries to convert to other codes as required. The switch assembly extends only six inches behind the mounting panel and allows stacking of 12 switches in less than five inches of length.

Instrument Systems Corp., College Point, L.I.

Flat face CRT 122

Du Mont tube type 5BWP is a high voltage, flat face cathode ray tube with 5-in. diameter face plate. Utilizing electrostatic focus and deflection, the tube has a spiral linear post accelerator from tube face to deflection plate region, allowing for a gradual voltage gradient.

It has high deflection sensitivity coupled with fast writing rate, astigmatism and pattern controls to insure distorionless displays. It is similar to the 5BHP except for increased voltage rating and a molded high voltage lead.

Bayly Engineering, Ajax, Ont.

Digital computer components 123

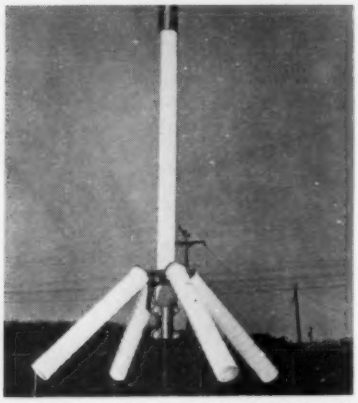
Included in Cambion's line of high speed (10 Mc) digital computer components are the and/or gate and the or/and gate. These geometrically identical modules are only 0.35 cubic inches in size and have a frequency response of dc to 10 Mc. The standard 7-pin base

permits easy insertion and removal for prototype work and programming.

Cambridge Thermionic of Canada Ltd., Montreal.

Communications antenna 124

Type 902 Helipole communications antenna is a new design employing a bifilar helical element in a Fiberglas

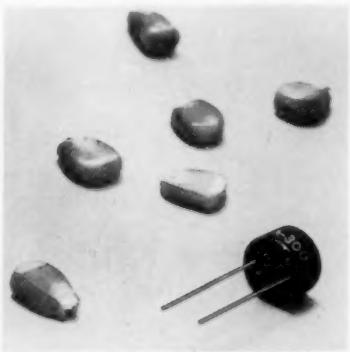


encased radiator. The ground rods utilize single helix conductors. Lightweight (13 pounds) and durable (30 psf with 1/2 in. ice), the antenna is intended for use with fixed stations in the 30-50 Mc range.

Andrew Antenna Corp. Ltd., Whitby, Ont.

Toroidal inductors 125

Burnell and Company's MT series of microminiature Kernel toroidal inductors is now being manufactured in Canada. First of the series, the MT 34 are recommended for frequencies to 30 kc



and can be supplied with inductances up to 500 mh. With inductances up to 200 mh, MT 35 Kernels are applicable to frequencies of 200 kc. Q for the MT 34 is greater than 55 at 25 kc, and for the MT 35 it is more than 60 at 100 kc.

Edo (Canada) Ltd., Cornwall, Ont.

Labels 126

These paper covered and electro galvanized labels and tags may be written upon with pencil, pen and fluid ink felt tip markers. They are available in plain or pre-printed form.

Barnard Stamp & Stencil Ltd., Hamilton.

New instruments—cont.

New ammeters and voltmeters 127

These portable instruments have 5.1-in. anti-parallax mirror scales, with knife-edge pointers, housed in bakelite cases. All instruments are supplied with individual calibration certificates.

Rectifier milliammeters and voltmeters type CPF have rated accuracy of 1% fsd. Ambient frequency influence is 1% from 20 cps to 20 kc. They have germanium diodes and are available in triple range units from 0.3 to 30 ma, and 3 to 300 volts.

DC moving coil ammeters and voltmeters type MPF have rated accuracy of ½% fsd using a self-shielded core magnet mechanism. They are available in single, triple and 17-range units from 3ua to 30 amps, and 0.1 to 1000 volts.

Stark Electronic Instruments Ltd., Ajax, Ont.

Direct reading L-C meter 128

Solartron L-C meter MM 906 for measuring inductance and capacitance has minimum full-scale ranges of 0-3 uh and 0-3 pf. It provides continuous monitor of L and C from 0-300 uh and 0-300 pf in five ranges with ±3% accuracy. This accuracy is maintained with resistance loads of 20,000 ohms shunt, 10 ohms series on 'Inductance' setting, and 0.1 megohms shunt on 'Capacitance' setting.

Instronics Ltd., Stittsville, Ont.

Transfer function analyzer 129

Gulton transfer function analyzer model OF-3 is applicable to vibration, acoustic, servo, human response and related fields. The analyzer uses a cross-spectral density computation technique for determining the response characteristics of control, structural and servo systems as well as electrical networks. It occupies the space of two 70-inch stand-

ard relay racks, gives output as Nyquist or Bode plots, operates with driving signals that are random or complex periodic in nature, and obtains the exact casual relationship between two signals.

Titania Electronic Corp. of Canada Ltd., Gananoque, Ont.

Meter calibrator 130

Mid-Eastern Electronics model 600 meter calibrator is designed for checking the operation of ac and dc volt and current meters, volt-ohm-milliammeters, VTVM's, panel and portable meters. The ac and dc voltage ranges are from 0-500 volts in seven steps; dc current ranges are from 0-500 microamperes in three steps, to 0-1000 milliamperes in ten steps. For checking ohmmeters, the model 600 incorporates a precision resistance decade ranging from 25 ohms to 2.5 megohms in seven steps. Accuracy on all ranges is ±0.75% of full scale, except ±0.2% on resistance ranges.

For applications demanding even greater accuracy, model 600A auxiliary unit may be used with the model 600 calibrator. It provides ±0.25% accuracy on all ranges. Heart of the unit is a Greibach model 700 Bifilar suspension light beam microammeter. This provides parallax-free readout with 0.1 second response time.

Willer Engineering & Sales Co., Toronto.

Selenium controllers 131

Designed and built in Canada, these new C.R. series selenium controllers embody a shunt circuit which provides a broad range of control. The new controllers replace 72 models and 13 box sizes with 5 models and 3 box sizes to take care of the control requirements of all Syntron vibrators and vibratory feeders. Controllers are CSA approved and adaptable for applications requiring timers, remote control, push button control, multiple feed rates, timed operating sequences, etc. Models are available in all standard voltage ratings.

Syntron (Canada) Ltd., Stoney Creek, Ont.

Automatic sweep drive 132

Sweep drive model AC-97C automatically sweeps oscillators and other tunable devices through their frequency ranges. It is particularly useful for Hewlett-Packard's model 302A wave analyzer. In this application, it sweeps through the entire range of the wave analyzer for automatic plots of harmonics, spurious responses or intermodulation products with an X-Y recorder. It also converts the model 302A to a sweep oscillator-tuned voltmeter for automatic frequency response measurements. Model AC-97C has two sweep speeds and a neutral. The fast sweep covers the frequency spectrum rapidly while the slow sweep gives a high resolution plot. In neutral you can tune the driven unit manually.

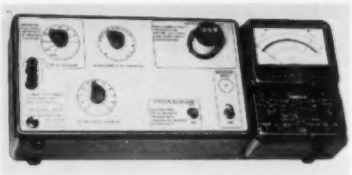
Hewlett-Packard Co., Palo Alto, Calif.

(Continued on page 64)

New instruments—cont.

Incremental multimeter 133

Incremental multimeter type 5880 enables increments of any range of the unit to be expanded about any point in the range and displayed on an external servo recorder. The entire package consists of a Simpson 270 multimeter to which are attached a suppressor power supply and an attenuator. Range and accuracy are identical to the basic Simpson #270 and its attachments. The range consists of over 50 different values of current, voltage, resistance, audio power, temperature and transistor characteristics. Typical accuracies are 1.5% dc and 2% ac.



Tensor Electric Development Co., Inc., Brooklyn, N.Y.

Panel meter 134

Model 1724 is a low cost ac meter in the Weston Crown line of panel instruments. With an accuracy of ±2% of full scale value, it is available as voltmeter, ammeter of milliammeter. Mouatings of the instrument are interchangeable with any 2.5-in. MIL Spec meter.

Normally adjusted for use on frequencies of 25 to 125 cps, the voltmeter can be adjusted for other frequencies up to 2500 cps. The nine voltmeter ranges available cover 0-5 volts to 0-500 volts. Ammeters and milliammeters are available for use on frequencies from 25 to 500 cps, but can also be obtained for use on higher frequencies. The five ammeter models range 0-1 A through 0-10 A; the four milliammeters are 0-15 ma through 0-500 ma.

Daystrom Ltd., Cooksville, Ont.

Sound spectrometer 135

Rapid analysis of noises having complex spectra is possible with Advance sound spectrometer type SPM.1. The instrument can also be used with a suitable vibration pickup for vibration analysis in the audio frequency range. The instrument consists of a small crystal microphone; a 6-stage amplifier, stabilized by heavy negative feedback; 8 band-pass filters which can be switched in at choice and a moving-coil meter with a db scale. An attenuator is built in with 5 steps of 10 db covering a range of 30 to 80 db, with an additional attenuator of 3 steps of 20 db covering a range of 0 to 60 db.

Smyth Electronic Components Ltd., Montreal; Conway Electronic Enterprises Ltd., Toronto.

New equipment—cont.

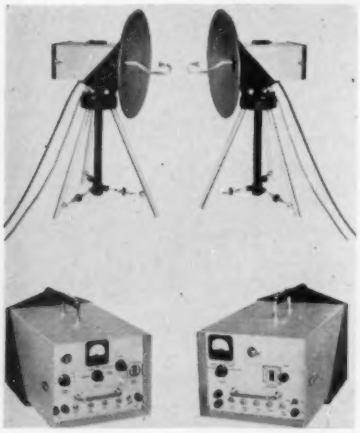
Precision welding head 144

Weldmatic model 1038 precision welding head is capable of performing single, series or parallel welds for electronic component assembly; joining fine wire, ribbon and foils; and for applications requiring a controllable fastening technique without the use of an interconnecting or bonding material. Operable with a range of stored-energy power supplies, the 1038 features 500 watt-second power rating, foot-pedal actuation, controllable electrode pressure and automatic firing.

Rudel Machinery Co. Ltd., Toronto.

Microwave relay link 145

Microwave relay link 420A/420AR, made by Electronic Systems Div. of Mechanical Products Inc., has a baseband width of 5 Mc (7 Mc optional), a power output of 0.1 watt and operating frequency range of 10.5 to 13.2 Mc. Features include: chassis that is removable



without disturbing case positioning or parabola, the mount for which is self-contained on the case; plug-in IF; built-in test meter for all tuning and voltage measurements; built-in signal attenuator.

Tele-Radio Systems Ltd., Toronto.

Trace-recording camera 146

C-12 camera utilizes a sliding back (adjustable to horizontal or vertical) on which you can interchange the par-focal, film-holding backs, lock them securely in 5 detent positions, also rotate them through 90 degree increments. It uses any of 8 interchangeable lenses in varying objective-to-image ratios and maximum aperture to f/1.5 with the lenses housed in uniform, pre-focused, calibrated mounts with keyed positioning threads (so that the shutter-speed and diaphragm controls always appear at the same place). The camera accepts Polaroid or any conventional film.

Tektronix, Inc., Willowdale, Ont.

(Continued on page 66)

New equipment—cont.

Personal radio pager 147

This personal radio paging system is capable of providing selective voice communications to more than 7,500 persons. The system operates in the 25-54 Mc

and 144-174 Mc bands enabling one-way communications between a central base station and individuals carrying Handie-Talkie receivers. For low capacity systems, a pushbutton control console is utilized with a regular two-way radio base station. The tone generators are included in the console. Up to 90 calls are provided with each console and four consoles can be used in a single system. A separate tone generating console is utilized for higher capacity systems along with a two-way radio base station and pushbutton control unit. The station can generate up to 7,656 individual calls.

Canadian Motorola Electronics Ltd., Toronto.

Photoelectric scanner 148

Farmer Electric Products Co. Inc. type PE7 scanner system combines a photoelectric scanner-relay and an adjustable electronic timer on the same chassis. Sensitivity ranges are from two inches to 18 feet with adjustable time delay ranges from 1.5 to 30 seconds. Scanning can be by direct or reflected light. Two separate single-pole double-throw relays have pull-in, hold-in, and drop-out characteristics that are determined by the way the unit is connected. Relay contact ratings are 8 amperes non-inductive at 125 vac.

Electrodesign, Montreal; John Best Co., Toronto.

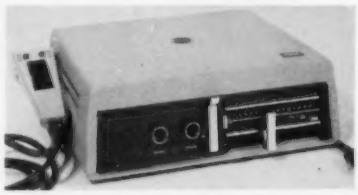
Tape transport 149

Type LAR 7500 laboratory analogue recorder can accommodate up to 14 channels of FM record and playback in one rack; six tape speeds can be selected from the front panel; tapes as thin as 0.65 mil base can be handled. Two basic models are available. One uses a tape width of ½", ¾" or 1"; the other uses widths of 1", 1¼", 1¾" or 2". The record/reproduce system accepts analog inputs within a bandpass of dc to 10 kc for as much as one hour of continuous recording. Incorporated in the FM unit are a re-record output for making duplicate tapes and a power output section to permit the use of direct writing instruments without the need for additional amplifiers.

Honeywell Controls Ltd., Toronto.

Dictation equipment 150

IBM has entered the dictation equipment field with its Executary which



uses a magnetic belt allowing an executive to correct his dictation before it goes to the secretary. The equipment will be available in units especially constructed for the secretary, for the executive, and constructed so that both could use the same machine.

International Business Machines Co. Ltd., Toronto.

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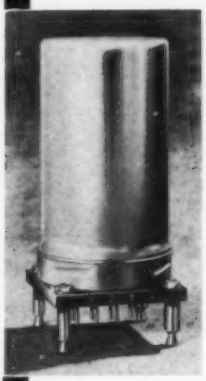

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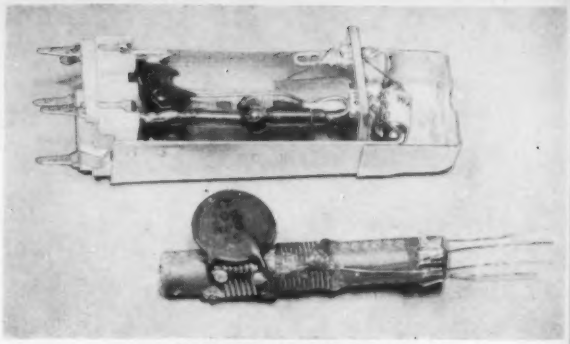

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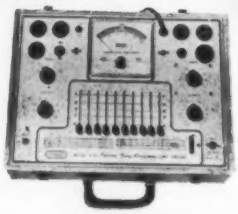

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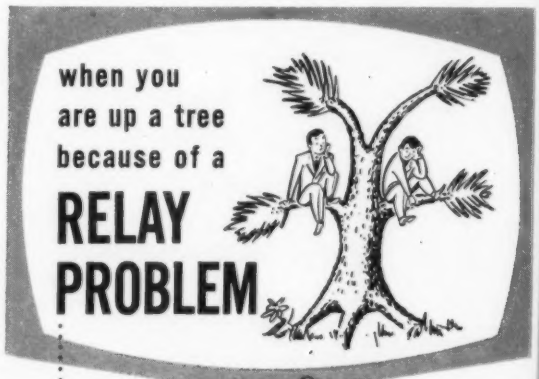

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Components to be discussed at symposium in Ottawa

Canada's three Armed Services are sponsoring a symposium on components April 11 and 12, 1961. Known as the Canadian Military Electronic Components Symposium, it will be held in the auditorium of the National Gallery, Lorne Building, Ottawa.

Dr. E. W. R. Steacie, president of the National Research Council, will deliver the keynote address. Four sessions will be held during the two days to discuss these topics: 1) Components research and development in Canada; four papers moderated by F. W. Simpson, DRTE/Electronics. 2) Components standardization; four papers moderated by Lt.-Col. W. H. Ellis, CAMESA. 3) Components reliability; three papers moderated by S/L A. E. Kelly, AFHQ. 4) Component production — DDP; three papers moderated by G. C. Rowe, DDP.

Invitations to industry members, and pre-registration of guests will be arranged by Electronic Industries Association of Canada. Further information may be obtained by writing to EIA at 200 St. Clair Ave. West, Toronto 7, Ont.

Chairman of the symposium is H. Reiche, Army Development Establishment, Ottawa.

British exhibitions

Britain's electronic component industry will have an eye on exports during the 17th Radio and Electronic Component Show, Olympia, London, May 30 to June 2, 1961. Overseas visitors will be admitted free. Exports of electronic components exceeded eleven million pounds Sterling last year and are expected to be higher this year.

The silver jubilee of television programming in Britain will be celebrated at the National Radio and Television Exhibition, Earls Court, London, August 23 to September 2, 1961. Television programs were first seen at Britain's Radio Show in 1936.

Technical papers wanted

The technical program committee is seeking papers for presentation at the technical sessions of the IRE Canadian Electronics Conference, to be held at Exhibition Park, Toronto, October 2-4, 1961. Papers may be submitted on any topic of interest to engineering, management, government or college members of the Institute of Radio Engineers. Topics may deal with any aspect of the electronics field, such as basic research, design, techniques, production, reliability and education.

Authors should submit 500- to 1,000-word summaries, from which the committee can judge the suitability of the paper for the conference. Summaries should be mailed to A. R. Low, Chairman, Technical Program Committee, IRE Canadian Electronics Conference, 1819 Yonge St., Toronto 7, Ont. Deadline for summaries is May 15, 1961. It is not necessary for an author to be a member of IRE.

Authors of selected papers will be asked to supply 100-word abstracts for inclusion in the Technical Program pamphlet. Biographies will also be requested.

Subject to approval, the technical program committee is considering publication of a digest of the selected papers. This would be available at the time of registration for the Conference. In that event, authors will be asked to submit diagrams with 500- to 1,000-word summaries in a form suitable for direct photographic reproduction.

NRC engineers win award

Four radio engineers of the National Research Council, Ottawa, have won the 1959 Brabazon Award for their work in developing an electronic aid to aircraft search and rescue.

The announcement was made by the British Institution of Radio Engineers, who offer the award each year for the most outstanding paper on aircraft safety to be published in their Journal. This is the first time the Brabazon Award, established in 1952, has been given for a paper contributed from outside Britain.

The recipients, D. M. Makow, H. R. Smyth, S. K. Keays, and R. R. Real, of the Council's radio and electrical engineering division, designed a distress beacon for a "crash position indicator" (CPI) developed by the NRC and now licensed for manufacture to a British electronics firm.

The CPI consists of a foam plastic shell which fits on the outer surface of the aircraft. Inside this protective sheath is a compact radio transmitter with a self-contained power supply. The whole device weighs only 5.7 pounds.

When the aircraft crashes, the CPI is so designed as to escape the impact; it flies free of the wreckage and automatically triggers its radio beacon. Search and rescue planes, using standard equipment, can pick up the signals as far as 40 miles away. The power supply of the CPI is good for about 100 hours.

COMING EVENTS

February

17-21 4th International Exhibition of Electronic Components, Parc des Expositions, Porte de Versailles, France.

20-25 International Symposium on Semiconductor Devices, UNESCO House, Paris, France.

Feb. 26-Mar. 1. Pacific Electronic Trade Show, Los Angeles.

March

16-17 Conference on data processing problems in engineering and scientific research, sponsored by The University of Arizona, Tucson, Ariz.

20-23 IRE International Convention, New York.

21-25 Electrical Engineers (ASEE) Exhibition Ltd., Earls Court, London.

April

18-19 Conference on organic semiconductor physics. Armour Research Foundation and "Electronics", Chicago.

May

3-13 British Columbia International Trade Fair, Exhibition Park, Vancouver.

7-12 89th Society of Motion Picture and Television Engineers Convention, King Edward-Sheraton Hotel, Toronto.

8-10 National Aeronautical Electronics Conference, Dayton, Ohio.

New products review

Many Canadian electronics manufacturers have been busy developing new components, instruments and equipment during recent months. Details of a selection of these latest Canadian product developments will be included in the March issue as a special feature of our annual New Products Review.

Free service for our readers

Keep your reference shelf up to datte this easy way. All advertisements, new products and literature in this issue have a key number. For more information

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easily convertible to a sweep oscillator-tuned voltmeter with this hp AC-97C Sweep Drive!

No calibration or stabilization is required with the hp 302A Wave Analyzer, a completely transistorized instrument which represents significant improvement in design. Operating as a highly selective tuned voltmeter, the instrument provides a front panel control which selects the frequency to be measured. Voltage then is read directly on the front panel meter. Basically, Model 302A separates an input signal into individual components so that each—the fundamental, harmonics and any intermodulation products—may be evaluated separately.

With the AC-97C Sweep Drive, the hp 302A is converted to a sweep oscillator-tuned voltmeter for automatic frequency response measurements, even in noisy systems. The AC-97C motor accessory permits sweeping the entire frequency range of the 302A, 20 cps to 50 KC; provides fast sweep for covering the spectrum rapidly, slow sweep for high resolution plot. The Sweep Drive with an X-Y recorder permits automatic plots of harmonics or intermodulation products. Model AC-97C attaches to the 302A panel, or may be bench mounted on an adjustable stand.

SPECIFICATIONS

hp 302A Wave Analyzer

Frequency Range:	20 cps to 50 KC
Frequency Calibration:	Linear graduation 1 division/10 cps. Accuracy ± (1% + 5 cps)
Voltage Range:	30 μv to 300 v, full scale, 15 ranges
Warm-up Time:	None
Voltage Accuracy:	± 5% of full scale
Residual Modulation Products & Hum Voltage:	Greater than 75 db down
IF Rejection:	Intermediate frequency in input signal rejected by at least 75 db down
Selectivity:	± 3½ cycle b.w. — at least 3 db down ± 25 cycle b.w. — at least 50 db down ± 70 cycle b.w. — at least 80 db down Beyond ± 70 cycle b.w. — at least 80 db down
Input Impedance:	Determined by setting of input attenuator: 100,000 ohms on 4 most sensitive ranges, 1 megohm on other ranges.
Dimensions:	20¾" x 12½" x 14½" (cabinet), 19" x 10½" x 13½" (rack mount)
Weight:	43 lbs. (cabinet), 35 lbs. (rack mount)
Price:	hp 302A (cabinet), $1,800.00 hp 302AR (rack mount), $1,785.00

hp AC-97C Sweep Drive

Sweep Range:	50 revolutions
Sweep Limits:	Any interval from 50 revolutions to 5 degrees
Sweep Speed with hp 302A:	170 cps/sec and 17 cps/sec
Mount:	Front panel of hp 302A or bench stand, adjustable, 4" to 12"
Price:	$275.00

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HEWLETT-PACKARD S.A.
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Sales representatives in all principal areas

UNIQUE NEW EIMAC 3CX10,000A3 CERAMIC TRIODE OFFERS VHF POWER—UP TO 20 KW

Eimac expands its ceramic tube line with the introduction of the 3CX10,000A3—the only 10 kilowatt air-cooled ceramic triode in the field. This advanced power tube is intended for use at maximum ratings through 110 megacycles.

An outstanding feature of this clean, efficient ceramic triode is the large reserve of grid dissipation assured by platinum-clad tungsten grid wires. Overload protection has also been built into the 3CX10,000A3 to make it ideal for use in industrial heating—dielectric and induction.

This newly developed triode is also well suited for such applications as broadcast, FM and single-sideband transmitters, ultrasonic generators and sonar pulse amplifiers. It can also be used as a class-AB_2 or class-B linear amplifier in audio or r-f service.

A companion air-system socket and chimney, as shown above, is available with the 3CX10,000A3 to meet your specific requirements. Watch for a low mu version of this high-power triode in the near future.

GENERAL CHARACTERISTICS EIMAC 3CX10,000A3 CERAMIC TRIODE	Height	Diameter	Max. Operating Temp.	Filament Voltage	Filament Current	Frequency for Max. Ratings	Max. Plate-Diss. Rating
	8.50"	7.0"	250°C.	7.5	100 amps	110 Mc.	10,000 watts

EITEL-McCULLOUGH, INC.
San Carlos, California

Canadian Representative: R. D. B. SHEPPARD,
2036 Prince Charles Rd., Ottawa 3, Canada.

6009

For further information mark No. 28 on Readers' Service Card